APRIL 1960

ie

ILLUMINATING ENGINEERING

Journal of the
ILLUMINATING ENGINEERING SOCIETY

Yes, you can order luminous ceilings by the "package"

Above: Wakefield Twenties in a private office

Right: Wakefield Twenties in a reception area

THE WAKEFIELD TWENTY

goes to the job ready to be mounted in about 20 minutes

Sounds too easy, doesn't it? But seeing this ceiling is believing! The fuss and bother of fitting together the various individual pieces of a conventional luminous ceiling are eliminated. Thus a 6 x 8 foot (48 sq. ft.) Wakefield Twenty can be mounted in about 20 minutes. The same area of conventional luminous ceiling would require considerably more assembling and mounting time for the same number of square feet. (Method is simplicity itself: an electrical channel along the back takes two sliding C clamp hangers; unit is lifted to ceiling and rods go from C hangers to pre-installed straps on ceiling.)

CONSIDER THESE FURTHER ADVANTAGES:

There are 5 standard sizes: 4' x 4', 4' x 6', 6' x 6', 4' x 8' and 6' x 8', so that with various combinations you can fit almost any area.

There are 3 types of diffusers: .060 styrene, .020 vinyl and 45° x 45° molded styrene louver.

When units are mounted side by side you can scarcely tell where they are joined. This is because the aluminum flange formed by the two sides is the same width as the removable aluminum cross tees. The result is the appearance of an unbroken luminous area.

We think The Wakefield Twenty is a natural for office relighting of all kinds, particularly rental office space. Plasterers and carpenters are not needed to lower a ceiling. Perimeter obstacles can be by-passed. Just mount one or more units as desired and you get low brightness, high intensity, large area lighting in a ceiling of modern height.

Our spec sheet and catalog give all the details. May we send them to you?

WAKEFIELD

THE WAKEFIELD COMPANY—VERMILION, OHIO
WAKEFIELD SOUTHWEST COMPANY—OKLAHOMA CITY, OKLA. 3745 N. W. 37TH STREET PLACE
WAKEFIELD LIGHTING LIMITED—LONDON, ONTARIO

THE ADVANTAGES OF KOOL KOIL COME AS TIME GOES ON....

ADVANCE Fluorescent Lamp Ballasts are built to last years and years operating under normal temperatures. The rigorous demands required of Fluorescent Lamp Ballasts today often result in ballasts operating at abnormal temperatures reducing ballast life by one-half for every 10°C heat rise over normal operating conditions.

To meet today's requirements, ADVANCE engineers, through more than 3 years' exhaustive research developed ADVANCE Kool Koil Fluorescent Lamp Ballasts. Tests in a standard 40° C Certified Ballast Manufacturers and Underwriters Laboratories' heat box proved KOOL KOIL Fluorescent Lamp Ballasts operated 16.5°C to 19.5°C cooler than other quality ballasts. Because they operate up to 20°C cooler, they give 3 to 4 times longer service . . . operate long after others have failed.

Insist on ADVANCE KOOL KOIL Fluorescent Lamp Ballasts for that extra protection now and the years of trouble-free service that will be yours as time goes on.

OPERATES UP TO 20° C COOLER

for extra years of trouble-free service.

GIVES 15% MORE LIGHT OUTPUT

for higher illumination levels.

ADVANCE

"The Heart of the Lighting Industry"

World's Largest Exclusive Manufacturers of Fluorescent Lamp Ballasts

TRANSFORMER CO.

2950 NO. WESTERN AVE. CHICAGO 18, ILL. U.S.A.

KEYSTONE'S ACHROMATIC

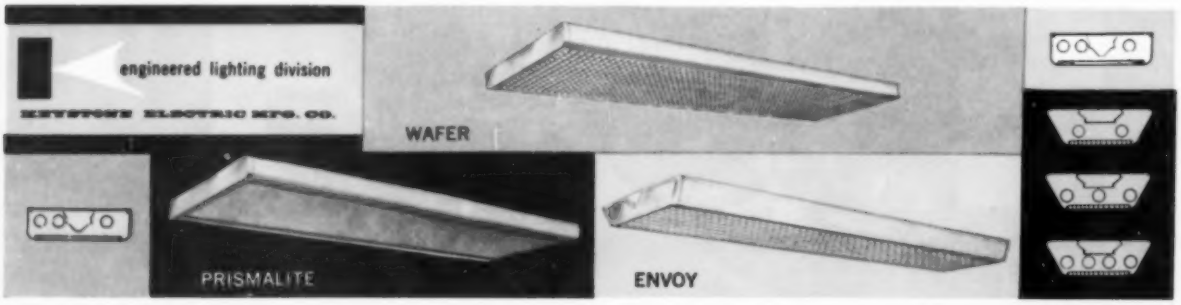
...FOR O.V.V.*

Keystone's Engineered Lighting Division recently announced a new series of fluorescent fixtures specially designed for schools, offices, stores, institutions and public buildings. Featured in this 4-foot and 8-foot series is the Achromatic, a 2 or 3 lamp quality luminaire which has become the industry's leader in a few short weeks.

Since 1898, footcandle levels have doubled every 10 years. Due to a more scientific evaluation of required lighting levels, the new series developed by Keystone has resulted in luminaires that provide *Optimum Visual Value and 'see-ability.' The series offers a brand new concept in controlled refraction of light. This concept provides uniformity of brightness without harsh shadow reflection. Maximum illumination is delivered at peak efficiencies. In addition to the Achromatic, other fluorescent fixtures in the new series include the Wafer, Prismalite and Envoy. Rapid start and slimline models are available for a number of versatile mounting arrangements. For additional information, send for Bulletin #F 859.

*optimum visual value

KEYSTONE ELECTRIC MFG. CO. *PHILADELPHIA 34, PA. SINCE 1932*



ie

ILLUMINATING ENGINEERING

THE JOURNAL OF THE ILLUMINATING ENGINEERING SOCIETY

April 1960

Vol. LV, No. 4

1959-1960 Officers

President
Joseph B. Browder

Vice-President
Richard G. Slauer

Vice-President
James R. Chambers

General Secretary
G. Franklin Dean

Treasurer
W. P. Lowell, Jr.

•

Editor
Ruby Redford

•

Advertising Manager
Clayton E. Ellis

•

Assistants
Barbara E. Marwell, Editorial
Adelaide Philiba, Advertising

•

Publications Committee
R. M. Zabel, Chairman
R. W. Morris, Vice-Chairman
Charles L. Amick
Brooks Chassaing
G. W. Clark
Floyd W. Sell
Nelson Warner

•

Managing Director
A. D. Hinckley

Technical Director
C. L. Crouch

Contents

191 Footcandles PLUS

197 IES Lighting Data Sheet—Series XXIV
Lighting a Railroad Classification Yard (11-8)

198 Practical Techniques Solve Off-Beat Lighting Problems

203 Programming the IBM 704 Computer for Photometric Data Reduction, Documentation and Application—Alfred B. Gough

215 Lighting Calculations for Thirty-Five Thousand Rooms—Philip F. O'Brien

227 IES Lighting Data Sheet—Series XXIV
Floodlighting a Building's Tower (24-31)

228 On the Foundations of Goniophotometry—D. E. Spencer and S. M. Gray

235 Questions & Answers on Light Sources

7A Lighting News
Here and There with IES Members, 6A; Scheduled Events, 17A; About People, 25A; Books and Pamphlets, 31A; New Members, 32A

37A Committee Personnel

51A IES National and Local Officers, 1959-1960

67A Index to Advertisers

Sustaining Members—Refer to March 1960 ILLUMINATING ENGINEERING

STATEMENTS and opinions in articles and papers in ILLUMINATING ENGINEERING are the expressions of contributors and do not necessarily represent the policies or opinions of the Society. Official Society opinions are expressed only in official committee reports specifically approved by the Council of the Illuminating Engineering Society.

ILLUMINATING ENGINEERING SOCIETY

EDITORIAL and advertising offices
1860 Broadway, New York 23, N. Y.

PUBLICATION office 32d Street & Elm Avenue, Baltimore 11, Md.

Founded 1906

ILLUMINATING ENGINEERING: The Journal of the Illuminating Engineering Society. Copyright 1960 by the Illuminating Engineering Society. Published monthly in the United States of America. Entered as second-class matter at the Post Office, Baltimore, Md. Acceptance for mailing at special postage rates provided for in Section 1103 P.L.&R., Act of October 3, 1917. Authorized July 16, 1918. ¶ Subscription $18 per year plus extra postage to all countries to which second-class postage rates do not apply; single copies $1.50. ¶ Address changes must be received at I.E.S. headquarters by the first of the month to be effective with the issue of the next succeeding month.

NOW . . . CONTROL LIGHT up, down and at 45°

with SHEFFIELD PLASTICS New Wrap-Arounds

FOR CUSTOM DESIGNS

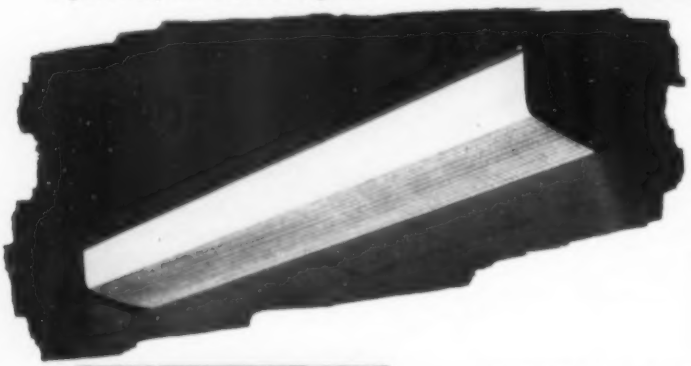
Directo-Lite*

Prismatic bottom provides . . .

- concentrated down-light
- excellent 45-degree cut-off

Prismatic sides provide . . .

- refracted light, down on work areas and up to ceiling
- excellent 45-degree cut-off
- glare-free, low surface brightness



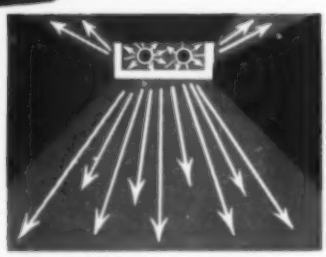
Tu-Tone*

Prismatic bottom provides . . .

- concentrated down-light
- excellent 45-degree cut-off

Two-color sides provide . . .

- attractive, 2-color effect at low cost
- glare-free, low surface brightness



45-Degree Cut-Off

and more efficient illumination on ceiling and work areas is provided by unique Directo-Lite prismatic design.

Sheffield's new extruded styrene wrap-arounds are the first such to provide directional control of emitted light. With them, fixture designers can obtain the high light transmission values of clear styrene, yet avoid its usual eye-straining, surface brightness. Use them in new designs or to give new life and sales appeal to an existing fixture. Your Sheffield technical representative will be glad to discuss your requirements.

WRITE FOR FURTHER DETAILS

on Sheffield Directo-Lite and Tu-Tone wrap-arounds. Complete technical data is readily available. Address your inquiry to Sheffield Plastics, Inc., Dept. 02-B, Sheffield, Mass.

*Trade mark

First in Plastics for Lighting

SHEFFIELD PLASTICS, INC.

SHEFFIELD, MASS.

SALES OFFICES

New York, N.Y. LO 8-3760 • Drexel Hill, Philadelphia, MA 6-4762 • Chicago: Bill Brown Sales Co., Inc. IR 8-8980 • San Francisco: Courtney Associates JU 5-5010

It takes more than footcandles to win a lighting contest. Lighting design, whether for a glamour bank or a utilitarian factory area, is the plus that makes a job even noticed any more. The following 1959 MMILJ entries have both elements: they meet the new IES recommended lighting levels, and they show thoughtful ingenuity in their design.

Footcandles PLUS

Church of the Immaculate Conception

Flexibility of lighting effects, unobtrusiveness to blend with the architecture, and ease of maintenance were the criteria for the lighting design of this church (photo A).

The main nave is 75 feet long by 39 feet wide, with a ceiling which is 36 feet high at the peak and 34 feet at the sides. On each side and back of the nave, under an 8-foot ceiling, there is additional seating in a space 20 feet wide. Along the sides of the nave at a 17-foot height, there is a catwalk hidden by vertical decorative wood panels. This catwalk carries the heating convectors and a cove for indirect lighting and, of course, makes relamping easy. The high outside walls above the catwalk are of colored glass and aluminum panels 17 feet high; the ceiling finish is flat white painted plaster.

The cove on each side uses 36 PAR38 150-watt floodlamps on two-foot centers, mounted in swivel holders on a continuous wireway. These lamps are focused approximately at the one-eighth points in width on the ceiling, to give a diffused indirect light throughout the nave. An occasional lamp is focused directly up to light the decorative high side walls and all lamps have individual louver shields to eliminate bright spots on the side walls, and protect the people in the balcony from glare. All of these lamps are on a motorized dimmer for infinite variation of light level.

With all lights on, the lighting level is exactly uniform from side to side of the main nave. This may be varied, however, at will. In addition to the dimmer control, the lamps are switched in six groups to provide further flexibility.

The lower part of the nave on each side and at the rear (not visible in the picture) has square

A

Church of the Immaculate Conception
Columbia Heights, Minn.
Designed by David C. Martin and Lyman C. Gross, Consulting Engineers, Minneapolis, Minn.
Twin City Section 1959 Contest, First Prize

recessed incandescent luminaires on two-foot spacings. These are switched in groups for varying light levels. The cove lighting extends into the sanctuary to provide the same type of indirect light for this area.

The balcony at the back of the upper nave is lighted with ceiling-recessed round cans using PAR38 150-watt floodlamps which may be stick-relamped from the balcony floor.

Altar and Crucifix are most effectively highlighted. This is achieved with six 150-watt and two 300-watt reflector spotlights concealed in the cove and focused on the Crucifix and Altar. In addition, a decorative canopy at the ceiling conceals fluorescent strip lights to further highlight the Crucifix and certain of the architectural features of the Sanctuary.

Architects for the Church of the Immaculate Conception are Shifflet, Backstrom, Hutchison and Dickey, of Minneapolis.

Fixture Manufacturing Area

Photo B-1 shows two "shoemaker's children" assembling custom-made luminaires under very very poor seeing conditions. With only 20 fc of general illumination, the benches are, of course, along the windows—if anything, worsening the situation with almost intolerable glare.

The other picture (B-2) shows a new location for this department, and well-designed lighting. The tasks consist of assembling small incandescent parts and hand-made custom luminaires. Most work surfaces have high reflectances and many are highly specular. Mistakes or damaged pieces for these low-volume hand-made units are costly, and so is lost time and/or late deliveries. The new lighting, to IES recommendations, has done much to avoid this.

The new area is 40 feet by 94 feet with an 11-foot ceiling. The long walls have large windows which face east and west, potentially creating an even worse daylight-glare problem than in the old area. However, the entire work area has been located in the center of the room, with electric illumination to provide the proper visual environment. Stock bins and such, have been placed along the window walls to reduce the daylight glare.

Brightness measurements in footlamberts are shown on the photograph. The values throughout are quite low, most critical brightness ratios being within 3 to 1, and only a few exceed 5 to 1.

Achieving readings of this sort would not be difficult with low footcandle levels; however, the system is designed for 110, and at the time the brightness readings were made it was providing 150 footcandles. (New IES recommendations call for 100 fc.) The luminaire chosen was a semi-specular Alzak aluminum industrial unit with approximately 25 per cent up-light and 35-degree crosswise shielding, especially designed to efficiently control the new 1400-1500-ma lamps. The installation consists of nine rows of four 8-foot units each

Fixture Manufacturing Area
Designed by Theodore Ake, Miller Co., Meriden, Conn.
Connecticut Section 1959 Contest, Third Prize

B-1

B-2

with two F96TD-17 lamps suspended on 8-inch stems and mounted on 10-foot centers.

A new heavy duty connector was used which enabled the electrician to assemble 16-foot sections at the floor; two men could then install the 16-foot units. This system required only four stems per 32-foot row.

It was felt that rather short suspension might create excessive ceiling brightnesses with a conventional 70 to 80 per cent white ceiling, so a light green with 60 per cent reflectance was used on both ceiling and walls. As shown in the photograph, ceiling-to-luminaire brightness ratios are about 3 or 3.5 to 1. The reduced ceiling reflectance lowered the coefficient of utilization only about 3 per cent.

The beams form 8-foot bays. The very low brightness ceiling in the foreground is one of two bays which does not have a row of luminaires. The rows were mounted across the area to provide maximum comfort and visual acuity, as well as to increase the apparent width of the room.

The 35-degree crosswise shielding reduces the brightness as viewed along the long dimension of the room as shown here. The pale green ceiling is reflected by the aluminum side panels, tending to blend them into a complete low brightness environment. No endwise shielding is required, it was felt, because only 13 feet of bare lamp is ever exposed in the direct glare zone. Much of this length is shielded by the power duct and tool rail. Lamps in adjacent rows are shielded from view by the wide reflector side panels. By placing the work benches perpendicular to the rows, they were able to achieve greater uniformity, eliminate line shadows caused by the power ducts and tool rails, and reduce reflected glare from specular surfaces.

The superintendent of the department reports greatly increased production and fewer rejects. Minor flaws can now be spotted quickly and easily repaired. In addition, he says, there is a 100 per cent increase in employee morale. Apparently the shoemaker's children really like their new shoes!

Rug Display

Another amazing transformation—this one from a gloomy bus garage to a modern retail rug shop. The entire brick front was removed and replaced with glass; inside the open steel trusswork was covered with a new suspended ceiling. This new hung ceiling consists of metal inverted T's spaced to hold a two-foot by four-foot ceiling tile with a matte white finish.

In photograph C the ceiling appears low. Actually it is comparatively high, 13 feet, and was one of the chief lighting problems. Others: a lighting system which would be suitable to the vast space and peculiarities of rug display, a light source to compliment the merchandise, and obtaining good vertical as well as horizontal distribution.

Since the ceiling was a new feature of the remodeling, the architect and lighting engineer had an opportunity to collaborate on its best height. Fourteen feet was at first considered. The final height of 13 feet was a solution to several factors—it gave suitable overall lighting efficiency and at the same time satisfied the architect's need

C

Rug Display
Designed by Russell W. Benjamin, The United Illuminating Co., Bridgeport, Conn.
Connecticut Section 1959 Contest, First Prize

for architectural balance in so large a room, and was the most economical for heating and air conditioning.

To make the huge ceiling look less obtrusive, a totally recessed lighting system was recommended. This is completely incandescent in order to create the desired "home" atmosphere, display colors in similar home lighting values, and minimize number of fixtures and still maintain good horizontal and vertical distribution. General lighting is from four two-foot square recessed silver bowl fixtures with metal louvers. These luminaires are mounted side by side to form a four-foot square. A total of four 200-watt silver bowl lamps are used in each four-foot square section.

In another huge sales room not shown in this picture, the vertical rug display against a side wall is lighted by single two-foot square recessed units around the perimeter of the display. In the front display area, 300-watt silver bowl lamps are used in each fixture. Adjustable eyeball units with 150-watt spots highlight rugs in window display. "Leaf type" rug display is lighted by using a louvered recessed incandescent reflector with an asymmetrical distribution to throw the light in between the rugs (not shown in photo).

Builder's Home, For Sale

Designed lighting, even on a low budget, made all the difference in the quick sale of this house. In planning this de luxe Scholz prefab for model and sale the builders (Weissert Construction Company of Butler) had, rather typically, allocated only $135 for lighting equipment. Modern electric appliances yes—lighting, hadn't thought of it. When they did think of it, at Mr. Laughner's behest, they agreed to let him work out a lighting plan, provided it was still under $500. In the end, this lighting design was the most talked-of feature in the house.

Photograph D is only one area of this well-lighted house, but it serves to illustrate the pleasing environment which has been created by the lighting. The area shown is one end of the living room and the dining "L" in the foreground. A 30-foot lighted valance equipped with rapid start homeline fluorescent lamps washes the draperies downward, provides upward general lighting, and imparts a feeling of spaciousness to the whole room. The valance is dimmer-controlled for flexibility of effects. Functional as well as decorative lighting is supplied by the portable lamps and the five-light modern pull-down unit adds sparkle to the dining room table.

The best home lighting effects are generally obtained by combining structural lighting with portable lamps and fixtures, and here we have a good example. Combine this with the wide range of illumination levels possible with the dimmer-controlled valance, and you have two rooms lighted for a variety of family moods and activities.

D

Builder's Home, For Sale
Designed by Jack Laughner and W. H. Roll, West Penn Power Co., Butler, Pa.
Pittsburgh Section 1959 Contest, First Prize

Clinton Savings and Loan Association

Customer's service area (bank) in Photo E shows what good lighting can do to rehabilitate a building which formerly housed a combination butcher and vegetable store. Lighting is interesting, appropriate to the area, and provides illumination values well above new IES recommended levels.

Luminous ceiling over the banking area is made up of two-foot square transparent acrylic plastic lenses supported by inverted transparent acrylic prismatic T-bars. These are suspended below fluorescent luminaires in continuous runs using 40-watt rapid start cool white lamps. These fixtures are ceiling mounted on 12-inch centers. The effect is one of natural daylight indoors. Over the public area and front window section, recessed downlighting uses PAR38 150-watt lamps.

With excellent brightness ratio values, the illumination readings were: First Teller—235 fc; middle teller, 250 fc; public area, 200 fc; customers' table, 148 fc.

Architect was Litwack and Shteir; electrical engineer, W. M. Helstrom, Public Service Electric & Gas Co., Newark, N. J.

E

Clinton Savings and Loan Association, Newark, N. J.
Designed by M. H. Silverman, Fluores-O-Lite Co., Hillside, N. J.
New Jersey Section 1959 Contest, First Prize

Chicago City Bank

This was once a clothing store. Its pleasing appearance and successful renovation as a banking office owes much to its lighting pattern. Completely harmonious with the architectural and mechanical design, and economically incorporating existing structural elements, it conforms also with IES recommendations for footcandle levels and brightness ratios from the working positions as these are laid out.

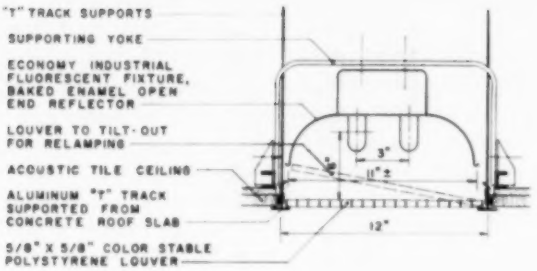
Originally the store was next door but has now been incorporated as part of the bank building. As with most remodeled installations, there were a number of existing structural and mechanical limitations. Air conditioning had been from four ceiling outlets; economical considerations indicated that the lighting design should be harmonious with the existing diffuser spacing so that the air conditioning duct work could be left as is.

In addition, with an irregular shape 80 feet long and 19 feet wide at the rear, but only 14 feet wide at the front, it was necessary to devise a lighting pattern which would blend with the asymmetrical ceiling plan. The solution (photo F and drawings F-1 and F-2) was a novel series of interlocking links. Both incandescent and fluorescent sources were used. This combination not only provided a suitable color balance, but also resulted in an extremely esthetic lighting pattern. The location of air conditioning ceiling diffusers remained unchanged; the only extra mechanical cost involved the substitution of two-foot square diffusers to replace the existing circular diffusers.

Although the luminous link fixture looks custom made, actually it uses a standard industrial fixture and a plastic louver (see drawing F-1). The openings for the luminous links were framed by the ceiling contractor similar to framing for recessed troffers. Next, aluminum T's were installed at the perimeter of the framed opening. The aluminum T's were supported from the concrete slab above the new dropped ceiling. Next, the industrial fluorescent fixture was supported from the ceiling channels by means of yokes similar to the supporting method of troffers. A polystyrene five-eighth-inch cell egg crate louver is then inserted on the aluminum T's. Adjacent sections of these plastic diffusers overlap, affording an unbroken continuous line of light. The louver tilts out for each lamp renewal.

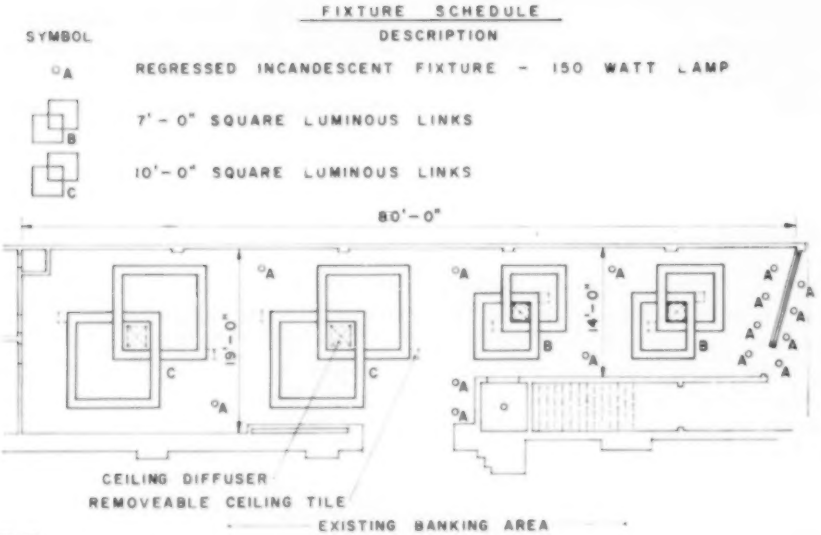
At the wider rear of the room, the luminous links (two sets) are ten feet square. These links are composed of four-foot and two-foot sections of

F


"T" TRACK SUPPORTS
SUPPORTING YOKE
ECONOMY INDUSTRIAL FLUORESCENT FIXTURE, BAKED ENAMEL OPEN END REFLECTOR
LOUVER TO TILT-OUT FOR RELAMPING
ACOUSTIC TILE CEILING
ALUMINUM "T" TRACK SUPPORTED FROM CONCRETE ROOF SLAB
5/8" X 5/8" COLOR STABLE POLYSTYRENE LOUVER
3"
11" ±
12"

F-1

Chicago City Bank
Designed by Melvin Cohen, A. Epstein & Sons, Chicago, Ill.
Chicago Section 1959 Contest, Second Prize



F-2

economy type industrial fluorescent fixtures laid end to end. Where the industrial fixture extends beyond the desired luminous pattern, a removable tile was placed below this section for easy access to the fixture. The louver panels are in three-foot and two-foot sections for easy handling. The continuous line of light, broken only at intersections of the 10-foot square gives the illusion of interlocking luminous elements.

Since the louver is separated from the fixture, the lamp to plastic spacing may be adjusted for maximum fixture efficiency and maximum uniformity of light around the entire luminous perimeter of the "links." In this installation the distance between lamp and plastic is six inches, a relatively large distance which it is felt will delay yellowing of the plastic louver by an additional two or three years.

At the narrower 14-foot front of the room, similar luminous links are seven feet square. These also use four-foot and two-foot industrial fluorescent fixtures and two- and three-foot louver sections. Thus all the louver sections can be removed at one time for cleaning purposes, with the sections interchangeable in either the seven- or 10-foot luminous links.

The system uses a total of 24 two-foot fixtures and 48 four-foot industrial units.

INSTALLATION AT THE DERAMUS YARD, KANSAS CITY SOUTHERN LINES, SHREVEPORT, LA.

Lighting a Railroad Classification Yard

LIGHTING OBJECTIVE: To provide general illumination without annoying glare for a railroad classification yard.

GENERAL INFORMATION: Most of the yard operations for Kansas City Southern Lines in this area are located at the Deramus Yard. From the tower of the yard office the yardmaster has an unobstructed view of the entire yard, which consists of about 60 miles of trackage. A two-way speaker system keeps the yardmaster in constant touch with yard crews.

INSTALLATION: A total of 122 Westinghouse type OV-60 luminaires, each equipped with a 1000-watt H18GV clear mercury lamp, is used for this installation. All luminaires are mounted at a height of approximately 35 feet above ground by Union Metal steel poles with 4-foot bracket arms. Along the switching ladder shown above, luminaires are spaced at 125-foot intervals and provide a maintained average illumination level of 2 footcandles over a 50-foot wide strip. Through the remaining part of the yard luminaires are mounted at 152-foot intervals on double arm poles in two rows 400 feet apart. This provides a maintained average level of 1 footcandle over an area of 110 feet in width, and a minimum of 0.2 footcandles at the most remote point in the yard.

Lighting designed by T. F. Howie, Electrical Engineer; Jack Moorman, Electrical Contractor; V. V. Kirkpatrick, Resident Engineer in Charge of Construction, all of Shreveport, La.

Lighting data submitted by C. D. Paine, Westinghouse Electric Corp., Shreveport, La., as an illustration of good lighting practice and to aid in the design of similar installations.

Published by the Committee on Publications of the Illuminating Engineering Society, 1860 Broadway, New York 23, N. Y.

Series XXIV
4-60

A.I.A. File No. 31*f*

Practical Techniques Solve

Parking Structure

Parking area lighting is essentially utilitarian, its aim—to provide sufficient light for safety and to minimize the danger of accidents and vandalism. Economy of operation, too, is an important consideration, especially in an area such as the one at hand, a 700-car municipally operated parking facility in Madison, Wis.

This five-ramp-level parking structure is a concrete reinforced building, open, except for one side which faces an adjoining building. Five acres of parking space are provided, approximately one acre per level, with two parking levels below grade and the top level, the open roof of the building. The facility is operated 24 hours a day, 7 days a week. Minimum maintenance was a major requirement for any lighting system, since only one man is employed to handle all maintenance.

The lighting system designed for the four enclosed levels of the building is based on the structural bays of the area. Each bay, 27½ by 60 feet, consisting of a driving aisle and three-car parking on each side, is lighted by three single-lamp 40-watt fluorescent luminaires. Fixtures are mounted parallel to the long axis of the cars, with the outside rows staggered one-half bay from the driving aisle. This staggered arrangement increases the uniformity of the light distribution because the outside rows of luminaires are mounted behind the structural columns. As an economy measure, the lamps were paired as much as possible, with one lamp having a two-lamp ballast, the paired lamp none.

Basic design level for the area was five footcandles, with the lighting level doubled for areas of greater traffic concentration. To reduce the tunnel effect experienced when driving from a bright street to the darker parking area, four-foot four-lamp fluorescent fixtures were installed at ramp entrances for a higher lighting level.

For the open top-level of the parking structure, 10 two-luminaire units with instant start ballasts, mounted on 12-foot standards, were installed on 80-foot centers around the perimeter of the roof. Each of these fixtures is equipped with four 40-watt fluorescent lamps. Four wall-mounted fluorescent units with 20-watt lamps, installed in the corners of the roof, 12 feet above ground, add to the uniformity of the light distribution.

Architects for this parking facility were Mead and Hunt, Madison, Wis.; electrical contractor was Cirves Electric Co., also of Madison. William C. Zimmerman, Paramount Industries, Inc., representative in Lake Mills, Wis., designed the lighting system and entered the job in the Milwaukee Section's 1959 MMILJ competition.

The basic criterion for a lighting installation is most often its practicality—does it provide the best luminous environment with the most efficient technique? In the installations shown here, all essentially "useful," common sense plus the skilled application of illumination principles combined to produce My Most Interesting Lighting Job entries in local IES competitions during 1959.

Off-Beat Lighting Problems

Museum of Man

Archaeological excavations of ancient civilizations have succeeded in revealing much about early man through the arts and artifacts that have survived the extinction of these cultures. On display in San Diego's Museum of Man is a valuable collection from the excavations of the ruins of the Mayan and Aztec Indians, two of the most highly developed civilizations in the Western Hemisphere in the pre-Columbian era. Invaluable for the effective display of these treasures is the museum's illumination system—a combination of general and accent lighting designed to reveal the beautiful and interesting details of this ancient sculpture.

The museum's prize exhibit is a group of three Mayan works, a 25-foot high monument silhouetted against a deep bay and flanked by two round five-foot monuments. The bay which provides the backdrop for the tall center monument is painted a light blue and lighted with 16 feet of two-lamp slimline fluorescent fixtures concealed behind ledges on each side of the bay. This serves not only as a dramatic backdrop for the central display of the museum collection, but gives diffuse general lighting to this area of the museum.

In front of these three monuments, following the path a museum visitor would take, a four-foot high railing of artificial planters has been built to conceal a lighting trough. The continuous trough is built on a 45-degree angle and equipped with a sand blasted glass cover to shield the lighting. For the two smaller monuments, 150-watt R40 spots are installed on one-foot centers in the trough. The tall central monument is lighted by two 150-watt

Detail of lighting trough behind planters.

PAR 38 lamps directed toward its base and center section, with a PAR 56 between them, aimed toward the top of the monument. Amber lenses used over the lamps soften the beams of light. At the back of the monument, a 500-watt PAR 56 lamp with blue filter is aimed at the ceiling to eliminate the shadows caused by the frontal lighting, the blue filter enhancing the blue of the high ceiling.

In the photo display area of the museum, hood fixtures directed down toward the display provide good lighting with a minimum of reflections and shadows. Display cases are lighted by continuous rows of single slimline fluorescent lamps, installed at the front and rear edges at the top of each case. Sheets of sand blasted glass under the lamps diffuse the light through the display cases with a minimum of glare.

At the entrance to the museum a valance is used to light the plaques on two side walls, an eight-foot two-lamp fixture concealed behind a beam floods the entrance and spots highlight interesting carvings above the entrance door.

Lighting designed by R. J. Huff, San Diego Gas & Electric Co., San Diego, Calif. This installation was awarded first prize in the 1959 MMILJ contest sponsored by the San Diego Section of IES.

Grease Pit

While the esthetics of lighting design are becoming increasingly important in many areas, it is reasonable to assume that for some installations the only requirement for the lighting system is that it be practical and serviceable—provide a comfortable level of illumination for the task performed, in the most efficient manner. One such area is an automobile grease pit, such as that operated by a Stockton, Calif. trucking firm, where a practical lighting system meant luminaires recessed out of the small work area and adequately protected from the liquids, vapors and rough treatment indigenous to the servicing of trucks.

To meet these specifications, Delmar L. Goodman, commercial lighting representative for Pacific Gas & Electric Co., in Stockton (Mother Lode Chapter, IES) designed a lighting system using four single-lamp eight-foot 800 ma fluorescent fixtures recessed in triangular troughs in the grease pit walls, directing light up to the work plane. For maximum utilization of light and minimum contrast between fixtures and surround, walls of the pit were painted white (75 per cent RF). To facilitate maintenance, fixtures were mounted on hinges and connected with seal-tight flexible conduit so they can be swung out of the recesses for thorough cleaning and relamping. Units are well gasketed for protection of lamps and sockets.

After 100 burning hours, illumination level on the underside of a truck being serviced measured 120 footcandles, exceeding the IES recommendation for this task and providing the service men with as pleasant an environment as could be found in any similar area.

Eight-foot fluorescent luminaires recessed in triangular troughs produce 120 footcandles on underside of truck.

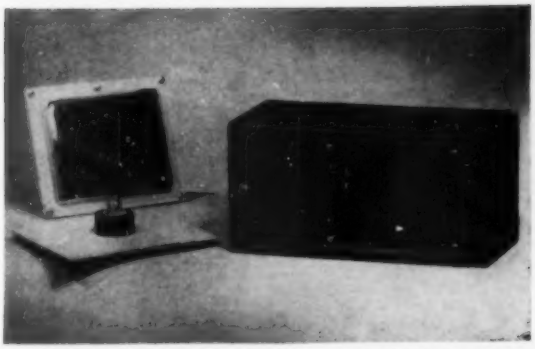
Hinged luminaires swung out of recesses for thorough cleaning and easy relamping.

Electroluminescent Safelights For Photographic Darkrooms

The illumination system for a darkroom where sensitive photographic materials are manufactured and handled is a highly specialized application. For safety of the photographic materials, light must be of an extremely low level (on the order of 1/200,000 of a footcandle) and of special spectral composition. White light must be excluded during all normal operations of the darkroom. Time, a factor of little importance to the effect of light in the usual installation, becomes an urgent consideration in darkrooms because of the cumulative effect of light on emulsions.

The general lighting system in a typical factory production area serves to illuminate such objects as instruments, wall clocks and obstructions, but in the darkroom these must be individually lighted, especially the obstructions, to ensure safety of workers and materials. In the past, the general practice has been to use incandescent safelights for darkroom illumination, but with the advent of electroluminescence, even in these early stages of the refinement of this source, the lighting industry seems to have found the ideal light source for darkroom illumination.

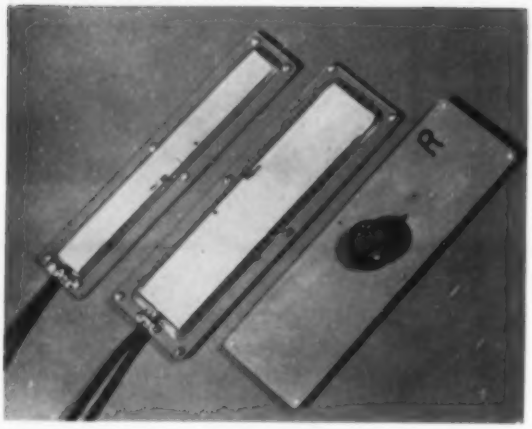
The electroluminescent panel, an electrical "sandwich" consisting of an electrically conducting surface, a layer of phosphor and another conducting surface, with at least one of the surfaces transparent, has several advantages for darkroom application. It has extremely long life, is easily dimmed, fairly rugged, easy to maintain and low in operating cost. Most important of all is its



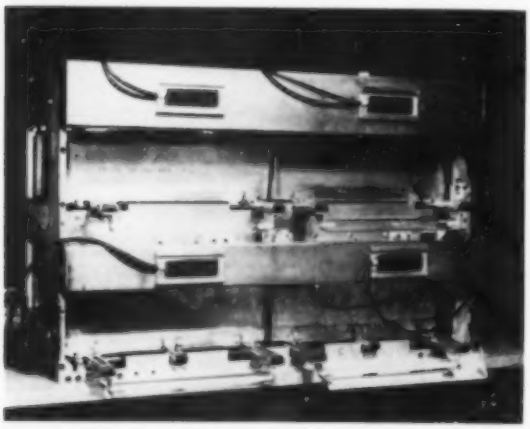
Four- by five-inch electroluminescent safelight (at left) contrasted with incandescent cast aluminum safelight having approximately the same light output and illuminated surface. Small size, simplicity and light weight of the electroluminescent safelight makes it far superior to the traditional one.

Several of the many possible sizes and shapes available with electroluminescent safelights.

Left: Component parts of 7- by 14-inch electroluminescent "Exit" safelight. From top to bottom: plastic back plate, electroluminescent panel, "Exit" film mask, transparent top cover. (Safelight filter not shown.) Photo below shows "Exit" safelight assembled from parts at left.



One- by ten-inch and two- by ten-inch electroluminescent safelights showing front and back views, plastic enclosures, cord and plug-in type.



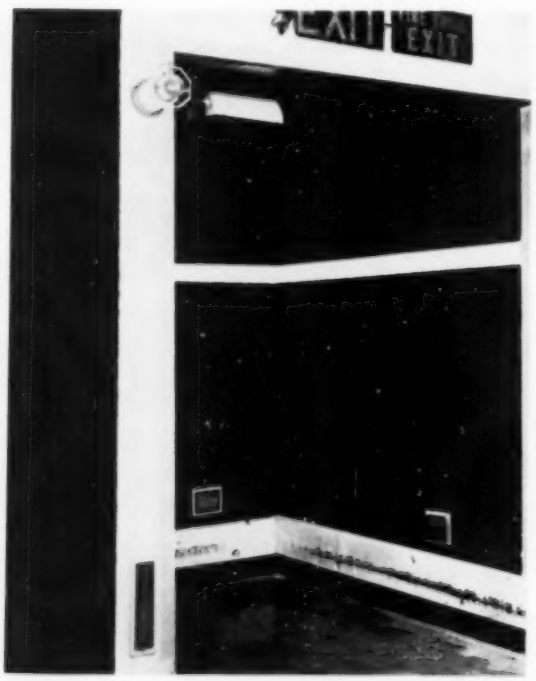
Safelights with suitable masks are mounted on a machine to indicate condition of work in the machine.

One- by four-inch electroluminescent corner type safelights mounted on conveyor corner near the floor to mark an obstruction.

extreme adaptability (see January 1E, page 10) in both size and shape.

Incandescent safelight housings have traditionally been fabricated from sheet metal or cast aluminum, requiring expensive tools, dies and machines. Housings had to be painted inside and out and many required mechanical or electrical interlocks so that the lamp would be de-energized when the cover was removed. In contrast to this, electroluminescent safelight housings are extremely simple plastic enclosures requiring neither painting nor interlocks. By means of a simple inexpensive vacuum process, these enclosures may be formed to meet almost any requirement. For example, a simple wood form, costing about $25, can be used to form hundreds of enclosures.

At the present stage in the development of electroluminescence, these panels are best utilized as guide lights, floor lights, aisle and exit lights, obstruction markers and general orientation applications peculiar to the requirements of film manufacturing areas. Several of these applications at the Eastman Kodak plant in Rochester, New York are shown in the accompanying photographs. Herbert S. Glick of the Kodak Engineering Division was responsible for these applications of this newest of light sources and his job won first prize in the Rochester Section's 1959 MMILJ contest.



Light lock leading out of a darkroom. Here electroluminescent safelights are used as guide lights near the floor and as exit signs over the door opening.

Programming the IBM 704 Computer

for Photometric Data Reduction, Documentation and Application

By ALFRED B. GOUGH

PHOTOMETRIC DATA of outdoor lighting luminaires and floodlights is recognized to be an important element in the information systems of lamp and lighting equipment manufacturers. Many of the systems now utilize some form of accounting machine such as the IBM 604 in their general operations. However, the current demand for testing and the subsequent volume of computational work requires that plans be made to include a high-speed digital computer as a key component in the information system.

The major problem in converting to high-speed computers from a desk calculator-long hand plotting method or even a small scale calculating machine is found largely in the programming phase. This paper first depicts the over-all photometric data information system. Emphasis is then placed on the key to efficient and successful programming which is the intricate and painstaking development of logical information flow diagrams.

Automatic processing of photometric data for street lighting luminaires has already been treated in previous years.[1,2] Here the high-efficiency 1500-watt floodlight is used as an example. The data reduction phase for one projector is carried one step further to system illumination calculations for an entire installation of floodlights on a football field.

Photometric Data Information System

In the early stages of planning for the introduction of a high-speed computer into an information system it is always advantageous to visualize the computer's relation to the rest of the system. Many policies need be established and decisions made. Where is the need for data recognized? Who initiates the actual tests? Who is responsible for the accuracy and validity of the raw data? In what manner is the data introduced into the computational cycle? What kind and how many error detection devices are incorporated in the system?

A paper presented at the National Technical Conference of the Illuminating Engineering Society, September 7-11, 1959, San Francisco, Calif. AUTHOR: Design Engineer, Outdoor Lighting Dept., General Electric Co., Hendersonville, N. C. Accepted by the Papers Committee as a Transaction of the IES.

The flow diagram in Fig. 1 is one highly accepted method of depicting the decisions and policies. At the top of the chart the need for the data arises from personnel in sales, marketing, development and design engineering, quality control and application engineering. The design engineer responsible for the product initiates the test and later coordinates the distribution of the final data. In this case with an automatic photometer, PAUDGET,[3] the laboratory supervisor and technicians are responsible for all phases of testing including the instructive loading of the automatic photometer and subsequent recording of data all on punched cards. Once the programming is completed and added to a systems magnetic tape unit, only the raw data and constants need to be loaded into the computer.

In addition to the internal checking and error detection features built into the program, it is possible to use the cathode ray tube, the error-stop core memory location and the post mortem (print-out of the status of index registers, core storage locations, accumulator, etc., when the error occurred) to locate the error. When the program runs to successful conclusion, approval is given to process the results for final reports.

Floodlight Photometric Test Data

The Illuminating Engineering Society has two approved guides which specify the photometric methods to be used in testing floodlights. The "IES Guide for the Photometric Testing of Floodlights of 10 to 160 Degrees Total Beam Spread"[4] provides the specifications for testing both electric filament and electric discharge lamps. The "IES General Guide to Photometry"[5] describes the general theories used in photometry and outlines the various types of equipment and methods of measurement.

This standardized testing of a single projector affords a discrete point-by-point array of raw data from which illumination calculations can be made. The increments between the individual points at which the raw data is taken are predetermined by

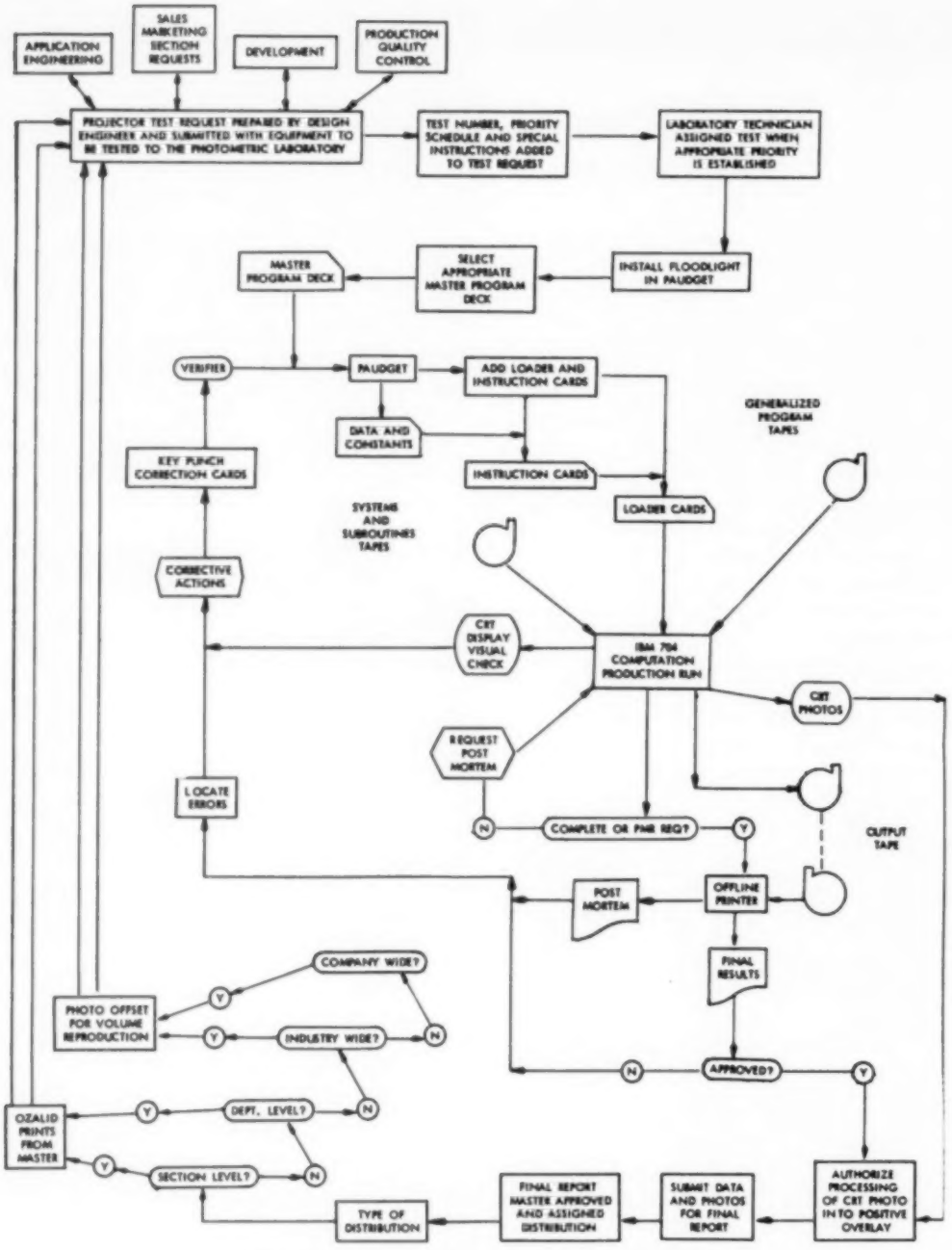


Figure 1. Photometric data information system.

a test run so that a complete 12 by 12 array of 144 points includes the measurable beam output of the fixture being tested. For example, a medium-beam floodlight with a total beam width of 35 degrees horizontal by 35 degrees vertical requires vertical and horizontal increments of 4 degrees between successive test points to insure that 144 points are evenly spaced over the light distribution pattern. For accurate and valid computation of the beam efficiency, 100 of these test points must be within the projected beam pattern. The beam has been defined to include all that light within 10 per cent of the average maximum candlepower. Average maximum candlepower is the average of ten highest readings excluding the values in the zero degree vertical and horizontal planes.

The IBM 704 Computer and Peripheral Equipment

The IBM 704 is a single-address, internally-programmed, high-speed computer. Accesss to any of the 32,768 words in magnetic core storage locations is 12 microseconds. Instructions require between two and twenty 12-microsecond cycles for execution. To achieve efficient on-line operation of the computer most of all the program input and output is accomplished via the magnetic tape units at 2500 words per second compared to 150 cards per minute for the on-line card reader. Off-line card-to-tape and tape-to-printer units are operated independent of the computer. Binary cards, loader, post mortem instructions and data decks, if short enough, are usually loaded through the on-line card reader.

The cathode ray tube 740 recorder and the 780 display unit complete the modes of output available on the computer. The recorder contains a 7-inch tube characterized by a raster consisting of 1,024 positions for the ordinate deflection and the same number for the absissa. Its positional stability is better than 0.1 per cent and a maximum error of 0.5 per cent positional accuracy has not been exceeded. The display unit contains a 21-inch cathode ray tube which displays the same 1,048,576 (1024 squared) points as that in the photographic recording unit. Data points are displayed on both tubes at a rate better than 7,000 per second. The 35-mm film frame advancement in the 740 recorder is controlled by the stored program. The film may be advanced about every half second if desired.

Internal Computer Elements[6]

To understand some of the terms used in the programming descriptions, some of the more important elements and features of the computer are discussed here:

The word or basic unit of information consists of 36 binary digits. A word may be an instruction or a number. A binary number of this size can represent all ten-digit algebraic numbers and eleven digit numbers less than 34,359,738,368. All words must first be brought into the accumulator or multiplier quotient portion of the arithmetic unit before performing the next operation with these words. Three special registers called index registers make possible the automatic counting and address modification features of the 704. Many instruction type words are made up of an operation and a storage address of the word upon which the operation is performed. Other more complex instructions have an additional "tag," which is the number of the index register to be used in counting or address modification, and a "decrement," which is the size of the modifying increment or step.

Symbolic Programming

Symbolic programming is a very useful feature which the assembly or compiler programs add to the already versatile machine. As mentioned above, instructions all have an address portion. For example, "CLA 527" means "clear the accumulator then add to it the contents of storage address 527." In this case we have used the absolute address 527 rather than a symbolic representation such as "A" or "B." It is also possible to use up to a five-letter symbolic representation to stand for location 527 and then let the assembly program assign the absolute location. Shown below are excerpts from programs coded first with absolute then with symbolic addresses. Depicted is a simplified portion of the program which takes the first data point (ACAN) in the column-by-column array of candlepower values, multiplies it by the appropriate zonal lumen constant (ZLC1) and stores the results in the first point of the column-by-column lumen array.

1. Absolute Addresses

Location	Operation	Address
1000	LDQ	1700
1001	FMP	2100
1002	STO	2200
	.	
	.	
	.	
1700	DEC	4655.0 (candlepower)
2100	DEC	0.00452 (lumen const.)
2200	PZE	0 (space for lumen value)

2. Symbolic Addresses

Location	Operation	Address
START	LDQ	ACAN
	FMP	ZLC1
	STO	ALUM
	.	
	.	
	.	
ACAN	DEC	4655.0
ZLC1	DEC	0.00452
ALUM	PZE	0

LDQ means load the multiplier quotient (MQ) with a value found at the given storage adress. FMP means floating point multiply the value in the MQ by the value at the address in storage. STO means store the value or results in the storage location specified. DEC indicates a decimal number. PZE stands for plus zero.

It does not take long to realize that absolute address programming is an involved and complicated process. Symbolic programming has several advantages.

(1) The pneumonic value of code words such as ZLC1, ACAN and ALUM afford ease of recognition, identification and reusage.

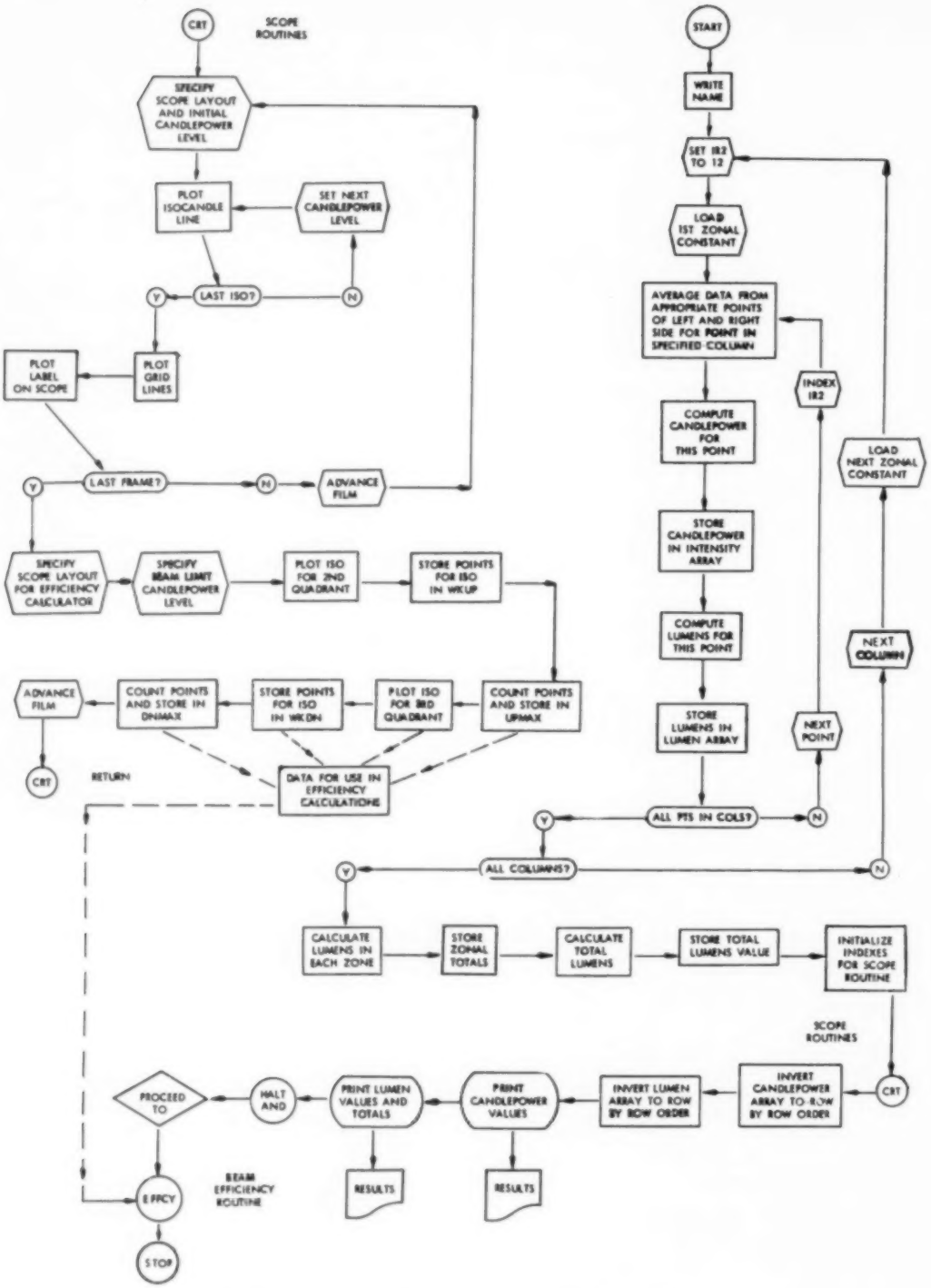


Figure 2. Logical diagram for data reduction routine.

(2) Use of code words rather than numbers introduces less errors.

(3) Programming is much more rapid because it is not necessary to keep track of the actual absolute address locations.

Note that later in the paper many of the flow diagrams refer to symbolic addresses in storage. Inasmuch as there is a five letter limitation many of the actual words have been abbreviated or spelled phonetically.

Data Reduction and Documentation

The data reduction and documentation phase includes all the data handling, computation, recording, curve plotting, interpolation, and final report preparation as recommended by the IES.[4] This includes total beam lumens, beam efficiency, isocandle (contour plot) lines, beam width, point-by-point candlepower and lumen values, and maximum and average maximum candlepower values.

Observe the logical designs of the program in Fig. 2. Note that the main program starts at the top right and stops near the bottom left. There are two major transfers from the main data reduction program; once to the cathode ray tube "CRT" subroutine for the isocandle plot and a second time for the beam efficiency determination, "EFFCY." The "CRT" logical diagram is located on the left side of Fig. 2.

A well planned logical diagram is the backbone of a computer program. It shows all the basic program blocks, the transfers, the indexing, the controls, the subroutines and the normal or error stops. Most programmers will agree that, once the mathematical analysis and flow or logical diagramming is accurately completed, the difficult part of the job is done. What remains in the form of coding, program testing and debugging usually is more time consuming than difficult. The early success of the coding, testing and debugging can be usually traced back to an efficient and precise logical diagram. For these reasons emphasis has been placed on the logical diagram in this paper. The main data reduction program and the two subroutines, isocandle plotting and efficiency determination, will now be more fully discussed.

Candlepower and Lumen Calculations

Starting with the 12- by 12-point array of galvanometer readings which are proportional to candlepower values, the program proceeds to average the output of the left and right sides of the beam. This reduces the array to 6 columns of 12 points each. Follow the action in Fig. 2 beginning at "START." Note that the first zonal lumen constant is readied after the index register is set to twelve. Successively each point in the column will be converted to candle-power and lumens; then stored in the proper array. The control and transfer instructions for this loop decrease by one the value of index register number 2 after calculations for each point. In this manner a test-type transfer instruction detects when the bottom of the column has been reached and sets into action the instructions which will reset the index register (IR2) and make ready the next zonal lumen constant.

After the point calculations have been carried out, the total lumens are determined and the candlepower array is searched for the ten highest readings. Ten per cent of the average of these values is the magnitude of the isocandle line which defines the beam area. The zero degree vertical and horizontal planes are computed also and appropriately stored. Information is now available for the isocandle plotting program.

Isocandle Plotting

To specify the scope layout and initialize the contour plotting routine, it is necessary to indicate the portion of the scope to be used by the array. An area 400 wide by 800 long with origin at X and Y equal to 100 leaves ample room for labelling. Horizontal and vertical grid lines which form squares 50 points per side on the scope represent, photometrically, squares which are 4 degrees horizontal by 4 degrees vertical with test points at their centers.

An enlarged print from the 35 mm CRT negative

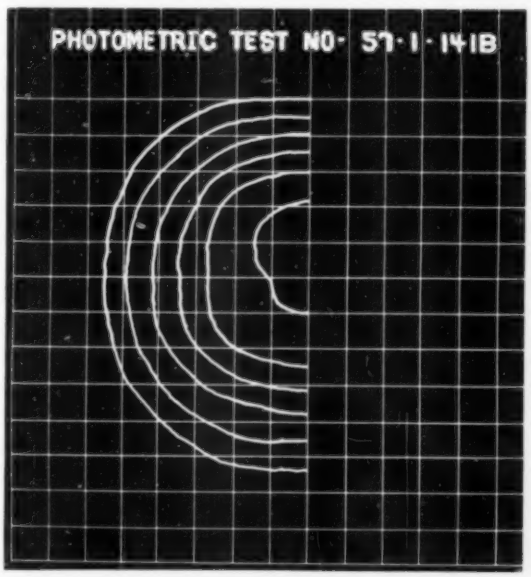


Figure 3. Enlarged print of 35-mm negative from IBM cathode ray tube output recorder. The family of curves and the X-Y coordinates represent floodlight isocandle lines and grids spaced at 4-degree horizontal and vertical intervals.

is shown in Fig. 3. The isocandle lines, the labelling and the grid lines, including the required candlepower calculations and interpolations were produced in 23 seconds.

Efficiency Determination

While the beam limit isocandle line was being plotted, the X and Y coordinate values assigned to it during the program were stored for use in the efficiency calculations. The coordinates of these points together with the grid locations and the lumen values for each grid square provide all the information necessary for the efficiency integration.

The summation used to obtain the total lumens within the beam limit line is exactly the same as the process used in longhand computation. Starting with the top left-hand grid square and proceeding along the row of squares, each square is searched to determine if any points from the beam limit line are in it. If not, the lumen value for that square does not contribute to the beam lumens. Finally in the fifth grid square, first row (see Fig. 3), points are detected and the program shifts to the integration loop. The purpose of this loop is to determine the per cent area of the grid square that is within the beam line. A simple but accurate graphical-type method is used to find the area. The individual grid square is divided into 10 columns and the average height of each column (as determined by the beam limit line) is multiplied by the column width. The values are summed to provide the area within the beam. The ratio of this partial area to the total grid area, when multiplied by the lumen value for the whole grid, provides the beam lumen contribution. Controls are set up so that grid squares further to the right in the same row contribute to the total lumen value even if not intersected by the beam line. This row-by-row process continues until all squares have been accounted for. The total lumens multiplied by two (to provide for the right side of the beam) and divided by the bare lamp lumens gives the beam efficiency.

When run with the main data reduction and plotting program, the entire computation including the efficiency determination requires approximately 40 seconds. An actual production run with magnetic tape input and output requires just under two minutes. Included in the two minutes is the added reliability of three complete isocandle line plots with separate photographs.

Floodlighting Systems Computations

Before starting w rk on involved system computations it is always necessary to make a check of the approximate time required to complete the run on the computer. For example, consider a football field to be illuminated with one hundred floodlights. To calculate the illumination at one specific point on the field it is necessary to know the angular orientation and location of every floodlight in respect to the specific point. Interpolation of the candlepower array for each floodlight will afford the contribution to the light intensity at the point. Additional computation using the generalized square law will provide the illumination in footcandles at one point from one floodlight. Certainly at least 100 test points will be required to adequately cover the area to be illuminated. With 100 floodlights and 100 points it will be necessary to make 10^4 single point illumination calculations. Next assume 10 trigonometric determinations per point at a minimum evaluation time of 10 milliseconds per function. This means that 0.1 second per point will be used in function evaluation and 1000 seconds for the whole system. For the main program also assume 50 algebraic manipulations. These manipulations require about 500 program steps per point or 5×10^6 program steps to complete the computer run. An average program step takes 9 cycles (12×10^{-6} second access per cycle) or about 10^{-4} seconds per step and 500 seconds to complete the program. At a bare minimum, then, the main program plus the function evaluations would take 1500 seconds or 25 minutes. Realize, however, that the results from this lengthy run reflect only the illumination values for the initial and approximate floodlight aiming specifications. To go through a refinement process which determines aiming specifications for optimum, even illumination on the field, many more of the same 25 minute loops would be required.

Many simplifications and approximations are used in the actual system to be programmed. Only one type of floodlight is used. The installation on one side of the field is symmetric with the other. The poles on which the floodlights are mounted are located along a straight line. The 10 floodlights mounted on crossarms at the top of each pole are all assumed to be located at the top center of the pole. Furthermore, the initial aiming and the number of floodlights will be assumed and estimated. Longhand tabular and graphical methods for arriving at the required number of floodlights have been described in earlier literature.[7,8]

Fig. 4 shows a typical floodlight aiming chart with the added grid and reference systems. All dimensions are set up in respect to the origin located at the intersection between the vertical line at the left end of the field and the horizontal line running through the poles on the near side of the field. Fig. 5 provides the angular and spacial relationships between the floodlights mounted at the pole

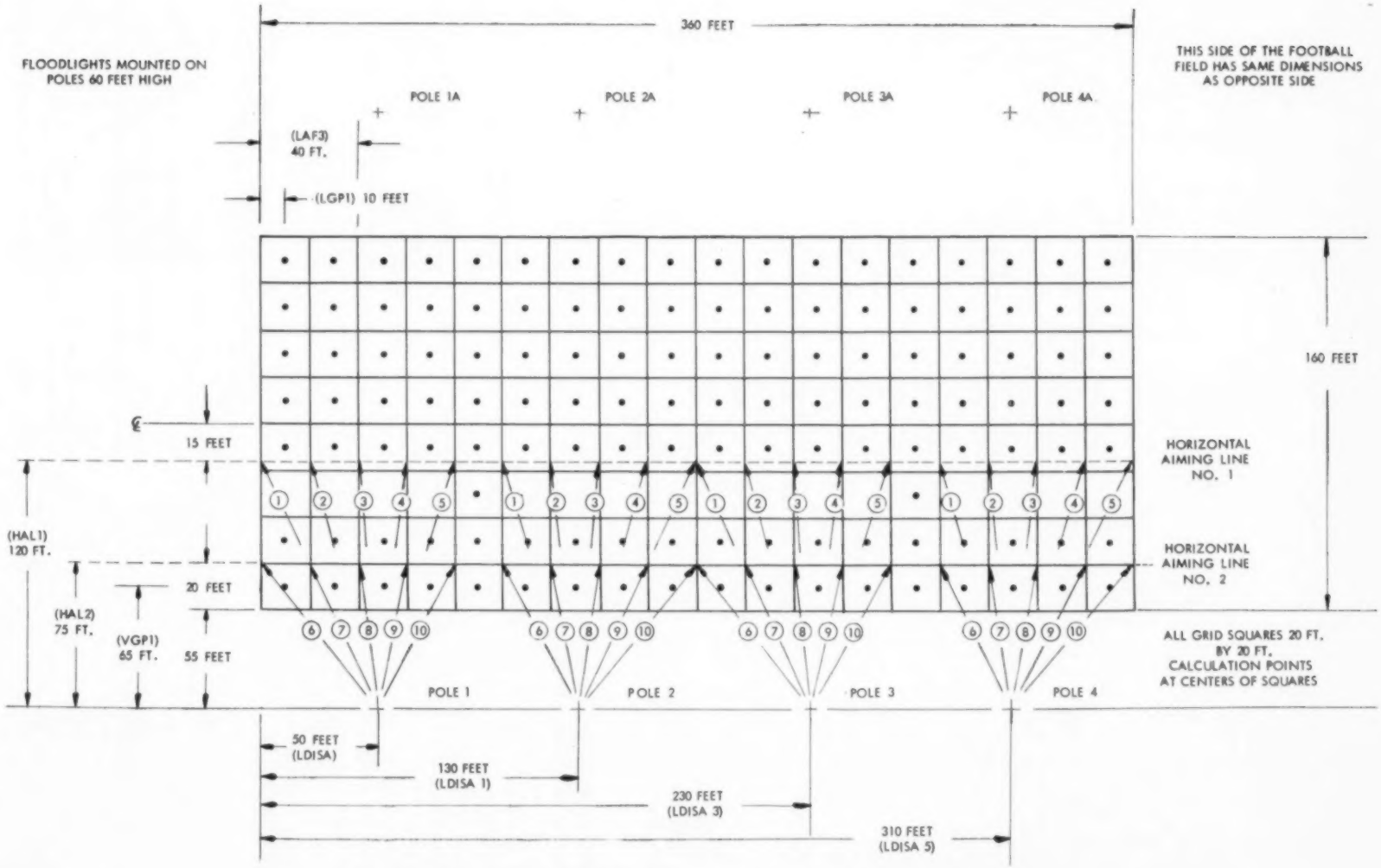


Figure 4. Reference and floodlight aiming system for the football field layout. Symbolic address code words used in computer program accompany the dimensions which remain constant.

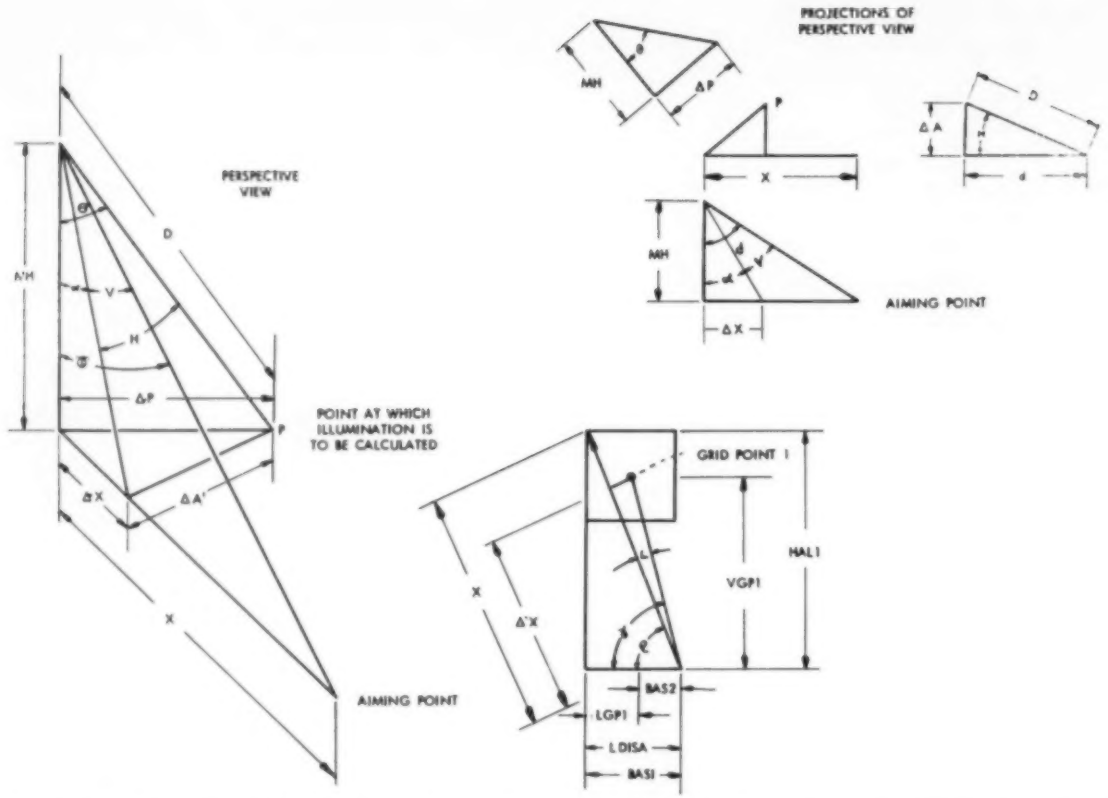


Figure 5. Trigonometric relationships for illumination calculations. Excerpt from Fig. 4 at bottom right shows grid point 1 and the angular relationships between a floodlight aiming point and a grid point.

top and the aiming and grid points. Note that in both illustrations symbolic address code words are used for the various distances. For example, "LGP1" means lateral distance to grid point number 1; "VGP1" for the vertical distance. "HAL1" and "HAL2" stand for the initial horizontal aiming lines number 1 and 2. "LAF1" represents the lateral distance to the point at which floodlight number 1 is aimed.

The following calculations are performed to arrive at the illumination, E (in horizontal fc), at one point from one floodlight. Letter and symbolic references are the same as those in Figs. 4 and 5.

$$\gamma = \tan^{-1} \frac{\text{VGP1}}{\text{LDISA}-\text{LGP1}} \qquad (1)$$

$$\rho = \tan^{-1} \frac{\text{HAL1}}{\text{LDISA}-\text{LAF1}} \quad \text{(horizontal floodlight aiming angle)} \qquad (2)$$

$$\Delta A = \frac{\text{VGP1}}{\sin \gamma} \sin (\gamma - \rho) \qquad (3)$$

$$\Delta X = \frac{\text{VGP1}}{\sin \gamma} \cos (\gamma - \rho), \; X = \frac{\text{HAL1}}{\sin \rho} \qquad (4)$$

$$\alpha = \tan^{-1} \frac{\Delta X}{MH} \qquad (5)$$

$$\phi = \tan^{-1} \frac{X}{MH} \quad \text{(vertical floodlight aiming angle)} \qquad (6)$$

$V = \phi - \alpha$ (vertical angular displacement from aiming point to the point where the illumination is being calculated; H is horizontal angular displacement) (7)

$$H = \tan^{-1} \frac{\Delta A}{d}, \text{ where } d = \frac{\Delta X}{\sin \alpha} \qquad (8)$$

$$\theta = \sin^{-1} \frac{\Delta P}{D}, \text{ where } D = \frac{\Delta A}{\sin H} \text{ and} \qquad (9)$$

D is the distance from the floodlight to the point of illumination calculations

$$E = \frac{\text{(candlepower at } H \text{ and } V) \; (\cos \theta)}{D^2} \qquad (10)$$

Particular care had to be taken during the programming to include test checks which would detect a zero in the denominator of any term and then

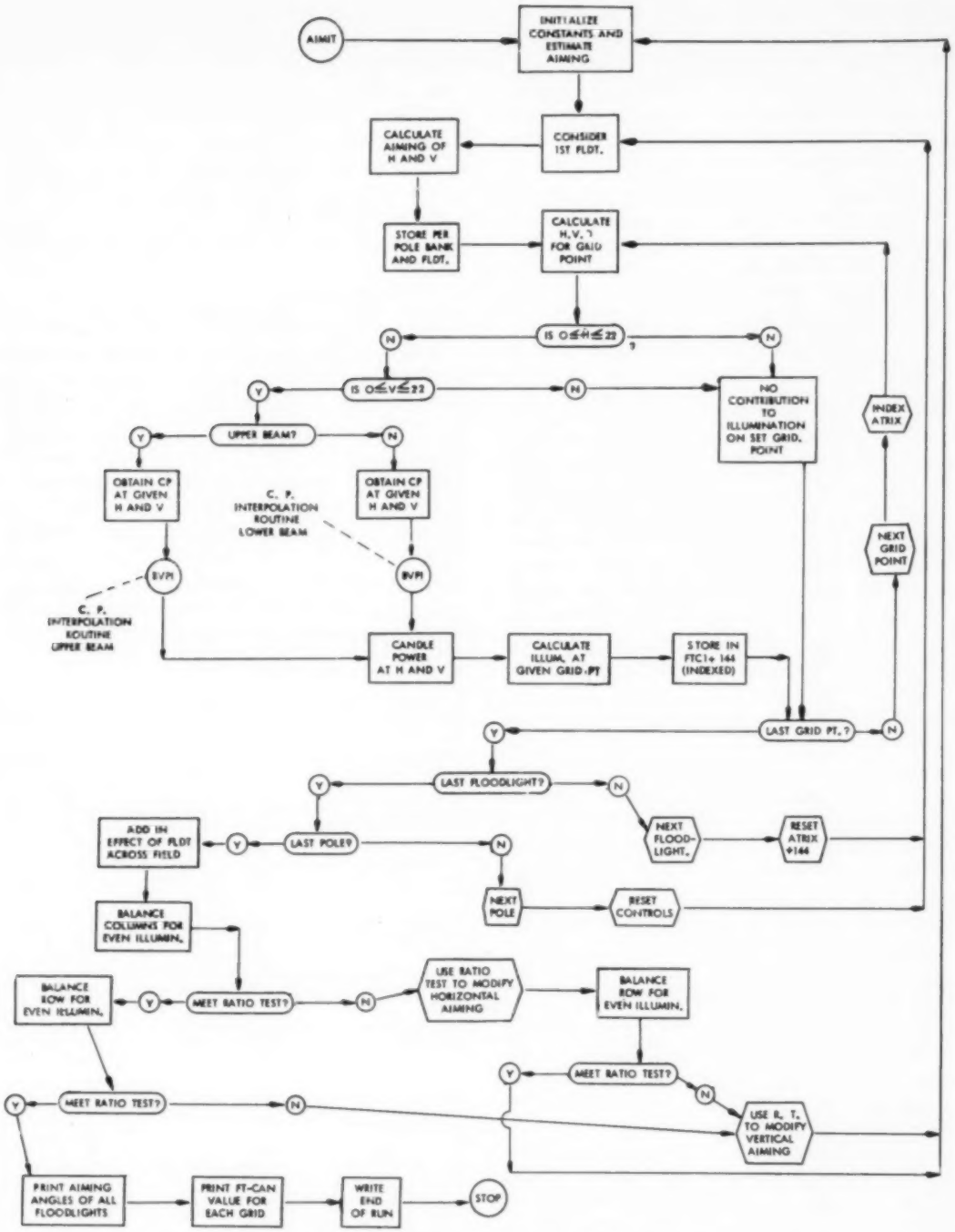

AIMIT
INITIALIZE CONSTANTS AND ESTIMATE AIMING
CONSIDER 1ST FLDT.
CALCULATE AIMING OF H AND V
STORE PER POLE BANK AND FLDT.
CALCULATE H, V, ? FOR GRID POINT
IS 0≤H≤22 ?
IS 0≤V≤22
NO CONTRIBUTION TO ILLUMINATION ON SET GRID. POINT
INDEX ATRIX
UPPER BEAM?
OBTAIN CP AT GIVEN H AND V
C. P. INTERPOLATION ROUTINE LOWER BEAM
OBTAIN CP AT GIVEN H AND V
NEXT GRID POINT
B/M
B/M
C. P. INTERPOLATION ROUTINE UPPER BEAM
CANDLE POWER AT H AND V
CALCULATE ILLUM. AT GIVEN GRID PT
STORE IN FTC1+144 (INDEXED)
LAST GRID PT.?
LAST FLOODLIGHT?
NEXT FLOOD-LIGHT.
RESET ATRIX +144
ADD IN EFFECT OF FLDT ACROSS FIELD
LAST POLE?
NEXT POLE
RESET CONTROLS
BALANCE COLUMNS FOR EVEN ILLUMIN.
BALANCE ROW FOR EVEN ILLUMIN.
MEET RATIO TEST?
USE RATIO TEST TO MODIFY HORIZONTAL AIMING
BALANCE ROW FOR EVEN ILLUMIN.
MEET RATIO TEST?
MEET RATIO TEST?
USE R. T. TO MODIFY VERTICAL AIMING
PRINT AIMING ANGLES OF ALL FLOODLIGHTS
PRINT FT-CAN VALUE FOR EACH GRID
WRITE END OF RUN
STOP

Figure 6. Logical diagram for illumination calculations.

provide an alternative path for the solution. Also note in Fig. 6 that if the grid point is greater than 22 degrees horizontally or vertically from the aiming point, the program shifts automatically to the next grid point.

The computer program proceeds (see Fig. 6) to make the point-by-point, floodlight-by-floodlight and pole-by-pole calculations based on the floodlights on one side of the field. Because of the symmetry of the system it is possible to add in the effect

of the floodlights across the field by a simple summation operation.

Once the initial illumination level has been determined it is then possible to go through a refinement and re-aiming process to provide even illumination on the field. The optimization system uses a column ratio test to compare illumination levels between columns. Depending on the magnitudes of the ratios, various adjustments are made in the horizontal spacing of the aiming points. Similar tests and modifications, if necessary, are made between rows. The illumination calculations are then repeated. When the ratios meet the specified requirement, the footcandle values and the floodlights' orientations are printed out.

Evaluation of the System's Computer Run

A complete production solution with optimization loops was not attempted because of the many hours of computer time it would require. A final test solution was run for 12 minutes prior to manually halting the computer and transferring to the printout routine. Results at that point indicated that one complete loop would be completed in about eight additional minutes. One complete loop here includes all the calculations required to determine illumination at each grid point for the initial setting of the floodlights.

These results indicate that, given a complete set of system aiming specifications, direct illumination calculations can be readily handled by the IBM 704 computer. However, at present, it is not economically feasible to use the program to determine and optimize the floodlight aiming diagrams on a day-to-day basis. In this case, the cost of programming the many different off-standard applications and the computer rental time exceeds the worth of the data obtained.

Future Lighting System Computer Programs

With the availability of a high-speed computer, the point-by-point calculation of footcandles appears to be the wisest. If the system is relatively small, or particularly non-uniform, a graphical or semi-graphical solution is recommended. By far the most promising answer is found in a different approach to the problem by treating the entire pole and bank of floodlights as a single projector. Tabulations of several aiming arrangements that span the available alternatives could be easily run off on the computer. The optimization problem is also reduced to 8 or 10 variables (the pole system) rather than 80 or 100 variables (the floodlight system). In fact, the pole (or floodlight bank) system tabulations could be prepared in such a manner as to afford excellent opportunity for visual inspection and choice of the most likely combination.

As it now stands, the illumination calculation program can be used as a tool in further research on lighting systems. Various parameters such as beam width, mounting height, and numbers of floodlights can be manipulated and their effect on the over-all system evaluated. Certainly the principles developed in this paper can be carried over to other types of general lighting systems as well as to the visibility and seeing evaluation studies now being carried on in the street lighting field.

Acknowledgements

The author wishes to thank the Massachusetts Institute of Technology for permission to publish material adapted from his thesis submitted in May 1958 as partial fulfillment for the Degree of Bachelor of Science at the School of Industrial Management. This work was completed during the 1957-1958 school year while the author was on leave of absence. Acknowledgment is also due the MIT Computation Center for its facilities utilized during the thesis preparation. In particular, thanks are expressed to Dr. F. M. Verzuh for the over-all thesis supervision and to Mr. T. H. Dupree for consultation on the contour plotting program.

References

1. Horton, G. A.: "Use of High Speed Computing Devices in Photometric Calculations," ILLUMINATING ENGINEERING, Vol. XLIX, No. 8, pp. 403-408 (August 1954).

2. Horton, G. A., and Zaphyr, P. A.: "Automatic Processing of Photometric Test Data for Street Lighting Luminaires," ILLUMINATING ENGINEERING, Vol. LIII, No. 6, pp. 341-351 (June 1958).

3. Franklin, J. S.: "Automated Universal Distribution Photometer," ILLUMINATING ENGINEERING, Vol. LIII, No. 12, pp. 667-678 (December, 1958).

4. "IES Guide for the Photometric Testing of Floodlights of 10 to 160 Degrees Total Beam Spread," ILLUMINATING ENGINEERING, Vol. XLVI, No. 3, pp. 163-168 (March 1951).

5. "IES Guide to General Photometry," ILLUMINATING ENGINEERING, Vol. L, Nos. 3 and 4, pp. 147-153 and 201-210 (March and April 1955).

6. International Business Machines Corporation, *Manual of Operation—704 Electronic Data Processing Machine*, New York: 1954, pp. 5-7.

7. Illuminating Engineering Society, "Current Recommended Practice for Sports Lighting," ILLUMINATING ENGINEERING, Vol. XLVI, No. 11, pp. 585-600, and Vol. XLVII, No. 2, pp. 109-117 (November 1951, February 1952).

8. Bock, J. E., and Swackhamer, R. J.: "Lighting the Yankee Stadium," ILLUMINATING ENGINEERING, Vol. 41, No. 9, p. 737 (November 1946).

DISCUSSION

P. A. ZAPHYR:* High-speed digital computers are being acknowledged as valuable tools in analyzing test data of all types of lighting systems. Several trends are becoming apparent as the power of this new tool becomes more available, as the effort involved in its use is reduced through automatic programming devices, and as electronic devices for recording data in a form amenable to direct processing on digital computers are being developed. The first trend is that of developing systems to perform more and more of the tasks of a repetitive nature necessary in lighting test

*Westinghouse Electric Corp., Analytical Dept., East Pittsburgh, Pa.

laboratories. Mr. Gough's paper describes a system for analyzing floodlighting applications which is completely automatized from the collection of data to the preparation of summary reports. A similar system for outdoor luminaires is described in his second reference, while a computer program for indoor luminaire test data analysis by the Zonal Method has been reported.[1] These three computer programs concern themselves with automatizing operations previously performed manually.

The next trend, introduced by the author's paper, is designing a lighting system. Although the design features considered in the paper are limited to only a few parameters, such as the horizontal spacings and the aiming points, it is conceivable that future applications may well select the type of luminaire to be employed, the number of luminaires and all details concerning their installation, the design criteria being that of producing lighting characteristics within the guaranteed performance at a minimum cost. Such complete design programs have been developed for other products such as large transformers[2] and induction motors.[3] Although it is not a simple task to develop such programs, the difficulties are not insurmountable. Computer economy considerations may make such a program impractical, as indicated by the author's concluding comments, but the development of faster methods of determining system performance, which seems possible, would eliminate that disadvantage.

The third trend is toward taking advantage of the power of digital computers and their widespread availability to develop better methods for evaluating lighting system performance, from the standpoint of accuracy. Previous methods have been restricted in complexity by the manual effort required to obtain results. Since digital computers can manipulate numbers up to six orders of magnitude faster than manual methods, it is reasonable to expect that methods of analysis developed for those computers will offer considerable improvements. The Illuminating Engineering Research Institute's Technical Advisory Committee on Predictions and Calculations has recognized that possibility and is currently initiating programs toward that end.

The advent of computers has presented an unprecedented challenge to researchers in illuminating engineering.

1. Zaphyr, P. A. and Horton, G. A.: "Calculation of Utilization Coefficients for Indoor Luminaires by Computers," ILLUMINATING ENGINEERING, Vol. LIII, No. 5, pp. 236-240 (May, 1958).
2. Moore, C. L., Duboc, W. T., and Zaphyr, P. A.: "Application of a Digital Computer to the Design of Power Transformers to Specification," *Transactions of the American Institute of Electrical Engineers*, Vol. 75, Par I, pp. 134-138 (1956).
3. Godwin, G. L.: "Optimum Machine Design by Digital Computer," to appear in the *Transactions of the American Institute of Electrical Engineers*, Paper No. 59-57.

P. F. O'BRIEN:* The use of high-speed digital computers to shorten the time required to perform routine lighting calculations and to increase the quantity of such calculations is well-outlined. Even more interesting, however, is the suggestion that computation loops which lead to better luminaire orientation for uniform illumination be employed. These iterative calculations can also be employed to optimize the design with respect to other performance criteria such as adaptation of the observer for particular lines of sight, initial cost of the system, and maintenance costs. Although detailed calculations of this type may not be justified for each installation, the lighting designer may wish to investigate a range of problems related to his specific application and product.

*Associate Professor of Engineering, University of California, Los Angeles, Calif.

G. A. HORTON:* On the first page Mr. Gough refers to "the instructive loading of the automatic photometer and subsequent recording of data all on punch cards." On the fifth page he mentions "starting with the 12 by 12 point array of galvanometer readings." This would seem to indicate that the photometric data is transcribed manually from reading a galvonometer, while my impression of the photometer used in this work was that it was entirely automatic, with the readings converted from analog to digital by means of a Fisher-Porter Digicoder and punched directly into punch cards.

In photometric testing of floodlights, I have noted particularly in narrow beam units that sometimes the total efficiency may be more than twice the beam efficiency based on light included within the beam limit, defined as all light within ten per cent of the average maximum candlepower. It appears that in these cases, the photometric exploration should be made to include the stray light as there may be some who would not otherwise be fully aware of the capabilities of these units. Since the photometric exploration and data reduction are apparently automatic, very little more would be required for a complete exploration once the programming has been accomplished.

Another case in which the photometric treatment might be improved over that recommended in the IES Floodlight Testing Guide (Reference 4 of the paper) is that in which somewhat linear sources, such as mercury lamps or axial filament incandescent lamps, are used in floodlights. In these cases, the beams are sometimes very narrow at the high and medium candlepower values but widen out considerably at the low candlepower values or beam extremities. In these instances, it might possibly be better to base the beam limit on ten per cent of the maximum candlepower rather than ten per cent of the average maximum candlepower but also include the stray light in the total efficiency.

The use of digital computers in floodlight application work brings within the realm of possibility a method using Utilization Curves for Floodlights.[1] This method appears to be more accurate than either the IES Lumen Method[2] or the "NEMA Method."[3] I believe that the chief objection to all these methods is the time and labor involved when they are done by hand. An excellent example of what can be accomplished along these lines by using computers is their application to the calculation of utilization coefficients for indoor luminaires by the IES Approved Method.[4,5]

In many sports arenas, the light component on a vertical surface is often more important than horizontal illumination for spectator vision. If a computer method which is not costly can be devised for determining vertical illumination, it would be another step in the right direction.

Since the volume of floodlighting application work is much larger than that of photometric testing, the main effort of utilizing computers should be along application lines. The detail programming is, of course, missing from the paper because of space limitations and, in addition, this is sometimes considered to be proprietary information.

1. Keck, M. E.: "Utilization Curves for Floodlights," ILLUMINATING ENGINEERING, Vol. XLV, No. 3, pp. 155-161 (March 1950).
2. *IES Lighting Handbook*, 1st Edition, Illuminating Engineering Society, New York City, 1947, pp. 8-25.
3. *NEMA Approved Standards*, National Electrical Manufacturers Association, New York City, 1953, Standard FL6-30.
4. Zaphyr, P. A. and Horton, G. A.: "Calculation of Utilization Coefficients for Indoor Luminaires by Computers," ILLUMINATING ENGINEERING, Vol. LIII, No. 5, pp. 236-240 (May 1958).
5. "Calculating Coefficients of Utilization," ILLUMINATING ENGINEERING, Vol. LI, No. 5, pp. 385-417 (May 1956).

*Westinghouse Electric Corp., Cleveland, Ohio.

A. B. Gough:* In general, the discussions by Professor O'Brien and Dr. Zaphyr have further emphasized the challenges which lie ahead for high-speed computer usage in the illuminating engineering field. It is in order to note here how some of these challenges are being met. One problem lies in the inefficiency of processing individual computer solutions for each new lighting application situation. In this case sometimes it is advantageous from both timing and economical standpoints to compute, at one time, a complete set of system performance data when parameters such as mounting height, spacing and reflectance factors vary. Thus, for a standard or new luminaire we would, in effect, be preparing a tabulated application handbook which spans all of the probable system combinations of the luminaire.

Other approaches lie in the area of minimizing the cost of programming. Subroutine library programs are becoming more complete and are extending into more engineering fields. Each computer user also builds up a special set of subroutines as he finds the need for particular computational phases recurring. Some of these shorter engineering and business mathematical terms have actually been incorporated into the basic computer command structure by means of assembly programs.

There are several points in Mr. Horton's discussion which require comment. First let me give an explanation of "starting with the 12- by 12-point array of galvanometer readings." This was really another way of trying to present a visual picture of the raw data or galvanometer readings as they were readied for computational phases in core storage. Actually, when PAUDGET[3] is used for floodlight photometric testing, the raw data is punched automatically into cards wtih a maximum of five separate readings per card. Computer input and loader programs extract this information from these data cards and transfer it to core storage.

Mr. Horton also suggests improvements in photometric testing procedures as recommended in the IES Guide.[4] Both of these recommendations could be easily handled by the computer with minor program modifications. Floodlight total efficiency calculation would, by necessity, require more test points but actually would be handled the same as beam efficiency calculations. The total efficiency could be calculated in less time than the beam efficiency because it is not necessary to determine zonal area percentages within the beam limit line. It also would be an easy matter as far as the computer is concerned to use ten per cent of the maximum candlepower rather than ten per cent of the average maximum candlepower to define beam limit. It was the intention of the paper, however, to work within existing photometric test standards.

In answer to Mr. Horton's last comment concerning the detailed computer program, I believe that he can find most of the basic programs listed in SHARE which is an IBM 704 computer users' organization. For example, the CRT isoline plotting routine is now listed in SHARE distribution #506 as MICR1 and MICR2. I would also recommend that the IES Testing Procedures Committee consider establishing a new "computations" subcommittee whose task it would be to develop and implement standardized computational methods and techniques. The analysis, computation and presentation of photometric data in terms of one, two and three standard deviation limits could also fall within the scope of this subcommittee. Such presentation of data would add a much needed dimension, namely, one of tolerance and variation in photometric data due to test methods and luminaire fixture manufacturing tolerances.

*Author.
Note: References are those of the original paper.

Turnpike Lighting with Low-Mounted Luminaires

Low-mounted (lamp centers are 38 inches above ground) fluorescent highway installation on New Jersey Turnpike using new combined reflector-aperture lamp. System provides broad horizontal light distribution, high vertical footcandle level for greater illumination on objects in vehicle's path and greater contrast between objects and road background than is possible with conventional overhead highway lighting systems under usual driving conditions. All light output is directed below driver's eye level for maximum comfort and minimum glare.

Lighting Calculations for Thirty-Five Thousand Rooms

By PHILIP F. O'BRIEN

The IBM 709 digital computer was employed to prepare a comprehensive table of quantities which specify the illumination and luminous emittance distributions in 35,000 rooms characterized by different geometries and reflectance distributions. Included in this paper is an abstract of this table describing the lighting distributions in 160 rooms which represent a realistic range of reflectances and room geometries. Square and infinitely-long rooms of identical domance k_r exhibit differences in luminous characteristics which are generally less than ten per cent. These data, based on a three-surface representation of the symmetrical room, may be employed to obtain detailed illumination and luminous emittance distributions.

Symmetrical Rooms of Various Proportions

The design of a lighting system often includes a prediction of the average illumination on the work plane and the illumination and luminance distributions within the room. For symmetrical luminous inputs in symmetrical rooms, this prediction is greatly simplified by the postulate that all spaces characterized by the same domance k_r* exhibit identical relative illumination and luminance distributions. As pointed out by Caracciolo,[1] Spencer[2] and others, the use of this geometrical parameter leads to calculated luminous flux distributions which differ from those values obtained by a more detailed consideration of the room geometry, that is, a square room, a circular room, a long finite room and an infinitely long room may all be characterized by the same domance but the illuminations of the various surfaces of this room are different. Data presented by Caracciolo and Spencer suggest that in large rooms of small k_r the error associated with this postulate involving the domance is small but in dark rooms of large k_r the difference between luminous transfer quantities in square and infinitely long rooms may approach fifty per cent. However, no comprehensive body of data has been published which reveals the magnitude of the difference between luminous quantities calculated for square and infinitely long rooms of the same domance and of realistic reflectance distributions.

In order to provide data which describes the luminous conditions in square and infinitely long rooms through a wide range of domance and room-surface reflectances, the nine transfer functions which were recently derived by O'Brien[3] were solved using the IBM 709 digital computer.** The techniques used to obtain these data and some comments on the use of the data to obtain distributions are contained in the following paragraphs.

Transfer Functions for Symmetrical Rooms

As pointed out by O'Brien and Howard,[4] the fundamental integral equation for flux transfer can be approximated by a matrix equation of the following form

$$\begin{vmatrix} +(1/\rho_1 - F_{11}) & -F_{12} & -F_{13} & \cdots \\ -F_{21} & +(1/\rho_2 - F_{22}) & -F_{23} & \cdots \\ -F_{31} & -F_{32} & +(1/\rho_3 - F_{33}) & \cdots \\ \cdot & \cdot & \cdot & \\ \cdot & \cdot & \cdot & \\ \cdot & \cdot & \cdot & \end{vmatrix} \cdot \begin{vmatrix} L_1 \\ L_2 \\ L_3 \\ \cdot \\ \cdot \\ \cdot \end{vmatrix} = \begin{vmatrix} L_{o1}/\rho_1 \\ L_{o2}/\rho_2 \\ L_{o3}/\rho_3 \\ \cdot \\ \cdot \\ \cdot \end{vmatrix} \qquad (1)$$

Luminous Transfer Matrix — Response Vector — Excitation Vector

A paper presented at the National Technical Conference of the Illuminating Engineering Society, September 7-11, 1959, San Francisco, Calif. AUTHOR: College of Engineering, University of California, Los Angeles, Calif. Accepted by the Papers Committee as a Transaction of the IES.

*The domance refers to the room proportions and has also been designated the index of room proportion or room coefficient; k_r equals the ratio of wall area to four times the ceiling area.

**The services of the Western Data Processing Center, University of California, Los Angeles, and of Engineering Aide B. R. Fink are gratefully acknowledged.

where:

$\rho_1, \rho_2, \rho_3 =$ luminous reflectance of finite areas A_1, A_2 and A_3, respectively.

$F_{nm} =$ the finite-finite shape modulus; the fraction of diffuse flux streaming from finite area n which is *directly* intercepted by finite area m.

$L_1, L_2, L_3 =$ the total average luminous emittances of finite areas A_1, A_2, and A_3, respectively.

$L_{01}, L_{02}, L_{03} =$ the initial (before interreflection) average luminous emittances of finite areas A_1, A_2 and A_3, respectively.

In a recent paper,[3] it was suggested that lighting analysis problems are concerned with obtaining a unique solution of Equation 1 for either the response vector (L_1, L_2, L_3 . . .) or the excitation vector (L_{01}/ρ_1, L_{02}/ρ_2, L_{03}/ρ_3 . . .). Lighting synthesis problems have as their objective the selection of an optimum combination of the geometry parameters F_{nm}, the reflectances ρ_n and the excitation vector. This optimum is with respect to auxiliary design criteria that may include visual, economic and esthetic parameters.

The luminance distribution or response vector is more accurately predicted by Equation 1 as the size or order of the luminous transfer matrix is increased, that is, the truncation error associated with the finite difference approximation is reduced as the number of finite surfaces representing the space is increased. Caracciolo, Dourgnon,[5] and others have advocated a three-surface approximation of the symmetrical room and this results in a three by three luminous transfer matrix. Analogue and digital computers may be employed for the direct numerical solution of Equation 1 over a range of geometries and reflectances, but there are certain advantages gained when closed-form expressions for the luminous emittances L are derived as a function of the ρ, F and L_0 distributions. These advantages include the identification of significant groups of the parameters (*e.g.*, the quantity $\rho/(1-\rho)$) and the easy computation of luminous transfer quantities which may not be contained in existing design tables.

Using the network representation of the three-surface approximation of the symmetrical room, O'Brien has recently derived the nine transfer functions which are a general solution to the response vector L_1, L_2, and L_3 of Equation 1, that is, these nine equations define the nine elements of the inverse of the luminous transfer matrix. The nine equations listed in Table I contain the parameters C_1, C_2, C_3 which are defined as follows:

$$C_1 = \frac{(1-\rho_1)(1-F^2)}{\rho_1(A_2/A_1)(1-F^2)+F(1-\rho_1)} \tag{2}$$

$$C_2 = \frac{(1-\rho_2)(1+F)}{1+\rho_2 F} \tag{3}$$

$$C_3 = \frac{(1-\rho_3)(1+F)}{1+\rho_3 F} \tag{4}$$

TABLE I — Transfer Functions of Symmetrical Rectangular Rooms.

RESPONSE	WALL EXCITATION – L_{01}	CEILING EXCITATION – L_{02}	FLOOR EXCITATION – L_{03}
$\frac{L_1}{L_{on}} =$	$\frac{1}{(1-\rho_1)}\left[1-\left[\frac{C_2+C_3}{C_1+C_2+C_3}\right]C_1\left[\frac{\rho_1}{1-\rho_1}\right]\left[\frac{A_2}{A_1}\right]\right]$	$\frac{1}{(1-\rho_2)}\left[\frac{C_2}{C_1+C_2+C_3}\right]C_1\left[\frac{\rho_1}{1-\rho_1}\right]\left[\frac{A_2}{A_1}\right]$	$\frac{1}{(1-\rho_3)}\left[\frac{C_3}{C_1+C_2+C_3}\right]C_1\left[\frac{\rho_1}{1-\rho_1}\right]\left[\frac{A_2}{A_1}\right]$
$\frac{L_2}{L_{on}} =$	$\frac{1}{(1-\rho_1)}\left[\frac{C_1}{C_1+C_2+C_3}\right]C_2\left[\frac{\rho_2}{1-\rho_2}\right]$	$\frac{1}{(1-\rho_2)}\left[1-\left[\frac{C_1+C_3}{C_1+C_2+C_3}\right]C_2\left[\frac{\rho_2}{1-\rho_2}\right]\right]$	$\frac{1}{(1-\rho_3)}\left[\frac{C_3}{C_1+C_2+C_3}\right]C_2\left[\frac{\rho_2}{1-\rho_2}\right]$
$\frac{L_3}{L_{on}} =$	$\frac{1}{(1-\rho_1)}\left[\frac{C_1}{C_1+C_2+C_3}\right]C_3\left[\frac{\rho_3}{1-\rho_3}\right]$	$\frac{1}{(1-\rho_2)}\left[\frac{C_2}{C_1+C_2+C_3}\right]C_3\left[\frac{\rho_3}{1-\rho_3}\right]$	$\frac{1}{(1-\rho_3)}\left[1-\left[\frac{C_1+C_2}{C_1+C_2+C_3}\right]C_3\left[\frac{\rho_3}{1-\rho_3}\right]\right]$

where:

ρ_1, ρ_2, ρ_3 = diffuse reflectances of walls, ceiling and floor, respectively.

F = shape modulus from ceiling to floor; fraction of diffuse flux streaming from the ceiling which is intercepted before interreflection by the floor.

(A_2/A_1) = ratio of ceiling area to the total area of all the walls.

The nine equations of Table I allow the computation of the ratio of response luminous-emittance L to the excitation luminous emittance L_0. That is, the ratios L_1/L_{01}, L_1/L_{02}, . . . L_3/L_{03} are dimensionless measures of the average response of a finite surface of a room to an excitation or input flux at the same or another finite area in the room. For example, the ratio L_2/L_{03} may be employed to compute the average luminous emittance of the ceiling L_2 when the initial (*i.e.*, before interreflections) luminous emittance of the floor L_{03} is specified. When initial luminous emittances exist at several finite areas which form the boundary of a space, the principle of linear superposition may be used as follows to compute the total response:

$$\bar{L}_n = L_{01}(L_n/L_{01}) + L_{02}(L_n/L_{02}) + L_{03}(L_n/L_{03}) \quad (5)$$

The uses of Equation 5 and related relationships for lighting design are described by Boast[6] in his excellent textbook.

An inspection of Equations 2, 3, 4 and Table I reveals that the geometrical characteristics of the symmetrical room are identified by the shape modulus F and the area ratio (A_2/A_1). Because $k_r = (1/4(A_2/A_1))$, all rooms of equal domance k_r also display equal ratios of ceiling (or floor) area to total wall area. However, rooms of equal k_r are characterized by a shape modulus F which depends on the room proportions. For example, a square room and an infinitely long room each of $k_r = 1.0$ are represented by shape moduli F of 0.200 and 0.236, respectively. As pointed out by Spencer,[2] the shape modulus F may be expressed as a function of k_r but the form of the function is defined by the room shape. An extensive tabulation of the shape modulus for various room shapes has been reported by Hamilton and Morgan.[7] The clear separation between the area ratio or k_r and the shape modulus in the equations of Table I allows the investigation of luminous transfer in rooms of constant k_r but different room proportions.

Another interesting feature of the transfer equations of Table I is the regular occurrence of the parameter $\rho/(1-\rho)$. In all cases the luminous emittance ratios are directly proportional to this reflectance parameter rather than to the reflectance alone. This suggests that tables of luminous transfer quantities should be computed for nearly equal steps of the ratio $\rho/(1-\rho)$. Existing tables conform rather closely to this suggested increment in reflectance.

Preparation of Tables Using IBM 709

In order to compare square and long rooms of equal domance over a wide range of reflectance and geometry, the equations of Table I and the auxiliary Equations 2, 3, and 4 were programmed for the IBM 709 digital computer of the University of California, Los Angeles. Because this computer is equipped with a relatively simple auxiliary machine language (*i.e.*, the Fortran System) the program consisted mainly in transcribing these equations into a notation which is recognized by the machine. Numerical values of the geometrical parameters (A_2/A_1) and F were recorded on punched cards in 35 combinations covering the range of interest. As each data card containing the geometrical information was fed to the machine, the solution of the nine equations of Table I was initiated for 1000 combinations of wall, ceiling and floor reflectance. The reflectance combinations were generated within the machine in response to certain cyclic incrementing instructions contained in the computer program. After each set of 1000 reflectance combinations for a particular pair of (A_2/A_1) and F geometrical values, a data card for a new pair of geometrical parameters was introduced to the machine and the operation was repeated. The computed values were read from the computer onto magnetic tape and later the taped data were transcribed to paper by a special tabulated machine.

The range of parameters utilized in this problem was:

$$0.1 \leq \rho \text{ (reflectance)} \leq 1.0$$
$$0.05 \leq k_r \text{ (domance)} \leq 3.0$$

By means of appropriate instructions in the machine program, the data for each room were printed on tabulating paper in the following format* with particular values chosen for example:

L1L01=3.050324 *L1L02*=0.532937 *L1L03*=0.566695 *ρ3*=0.50 *ρ2*=0.80 *ρ1*=0.80
L2L01=2.131749 *L2L02*=1.395248 *L2L03*=0.589201 *H*=2.00 *D*=1.00
L3L01=1.416739 *L3L02*=0.368251 *L3L03*=1.286004 *A*=0.25 *F*=0.236068

where:

L1L01 ≡ L_1/L_{01}, etc.
ρ3 ≡ ρ_3, etc.
H ≡ ratio of room height to room width.
D ≡ domance.
A ≡ ratio of ceiling area to total wall area.

*The symbols actually employed in the machine format were slightly different from those reported here.

$F \equiv$ shape modulus for floor to ceiling transfer.

Ten units of the above output format were printed on each page and a total of 3,500 pages was required for the entire table. Note that this format is arranged in the usual matrix form and, in addition, the format matches the order of transfer equations presented in Table I. The elements of this format are simply related to the elements of the inverse of the luminous transfer matrix as defined in (1).

The total table of 3,500 pages contains 315,000 computed values which identify the luminous response vector in 35,000 rooms. The time required for these computations by the IBM 709 was about two hours while it is estimated that four man-years would be required for the same computations with a desk calculator.

Square and Infinitely-Long Rooms Of Equal Domance

Some values of the transfer ratios Lu/Lom which describe the conditions in 160 pairs of square and infinitely-long rooms of equal domance have been extracted from the original IBM table and are reported in Tables II through X. The range of domance k_r and reflectance ρ employed in these abridged tables is similar to that reported by Boast. The upper value in each of the paired groups contained in Tables II through X is identified with a square room (note: $k_r =$ (room height)/(room width)) while the lower entry is for an infinitely long hallway (note: $k_r =$ (room height/2(room width)).

In general, the data of Tables II through X reveal that in rooms with light surfaces the difference between emittance values for square and long rooms is less than eight per cent while slightly darker rooms do not display differences much greater than about 12 per cent. For example, the rooms with $k_r = 1.0$ and with the reflectance combinations ($\rho_1 = 0.5$, $\rho_2 = 0.7$, $\rho_3 = 0.3$) and ($\rho_1 = 0.3$, $\rho_2 = 0.5$, $\rho_3 = 0.1$) are reported in Tables XI and XII, respectively. The group of five numbers associated with each transfer ratio in Tables XI and XII may be identified by reading from the top as follows using L_2/L_{o3} of Table XI as an example:

	0.254	= square room
	0.274	= infinitely-long room
L_2/L_{o3}	0.199	= interflection method*
	+ 7.9	= per cent difference between the square and long room; based on the square room value
	−21.6	= per cent difference between the square room and the interflectance value; based on the square room value.

As shown in Tables XI and XII, the difference between square and long rooms is generally quite small. This suggests that the concept of the domance is applicable through this extreme range of room proportions. The rather large difference between the square room and interflectance values is partly associated with the exponential approximation employed for the shape modulus F. When this exponential approximation is removed from certain values, as suggested by Spencer, this difference is reduced significantly. One feature of Tables II through X is that only exact shape moduli were employed and, for this reason, the sole significant error is associated with the truncation effect at the walls, ceiling and floor. Errors associated with both the truncation effect at the floor and ceiling and with the approximate shape modulus are characteristic of the existing tables based on the interflectance method.

Detailed Distributions of Luminous Flux

Although the three-surface representation of the symmetrical room provides the average luminous emittances of the surfaces, the detailed illumination and emittance distributions can be computed using these average values such as listed in Tables II through X. The illumination at any differential surface element within or on the boundaries of a room is simply the sum of the products of the differential-finite shape moduli with respect to the surface element and the average luminous emittances. For example, the illumination at location S on the wall of a long hallway is given by the relationship:

$$E_1(S) = F_{d1\to1}L_1 + F_{d1\to2}L_2 + F_{d1\to3}L_3 \qquad (6)$$

where:

$E_1(S)$	=	the illumination on the wall at a location S units distance from the ceiling.
$F_{d1\to1}$, $F_{d1\to2}$, $F_{d1\to3}$	=	the differential-finite shape modulus; fraction of diffuse flux streaming from dA_1 which is directly incident on finite areas A_1, A_2 and A_3, respectively.
L_1, L_2 L_3	=	the average luminous emittances of the walls, ceiling, and floor, respectively.

Using the numerical data for the long hallway ($k_r = 1.0$, (height/width) $= 2.0$, $\rho_1 = 0.8$, $\rho_2 = 0.8$, $\rho_3 = 0.5$) reported in the sample IBM format contained in the text above, the illumination at the center of the wall is given by Equation 6 as follows:

*Values reported in Chapter 12 of the textbook by Boast.

TABLE II — Component Wall Lighting. L_1/L_∞. L = Luminous Emittance; ρ = Reflectance. Subscripts: 1—Wall; 2—Ceiling; 3—Floor; Upper Entry—Square Room; Lower Entry—Infinite Hallway.

ρ_2	0.8				0.7			0.5		
ρ_1	0.8	0.5	0.3	0.1	0.5	0.3	0.1	0.5	0.3	0.1
k_r										
					$\rho_3 = 0.1$					
	1.2097	1.1215	1.0695	1.0222	1.1154	1.0662	1.0211	1.1037	1.0597	1.0191
0.1	1.1765	1.1034	1.0596	1.0191	1.0971	1.0561	1.0180	1.0848	1.0492	1.0159
	1.3778	1.2068	1.1146	1.0355	1.1959	1.1090	1.0339	1.1748	1.0980	1.0307
0.2	1.3573	1.1969	1.1095	1.0340	1.1856	1.1037	1.0323	1.1639	1.0923	1.0290
	1.5628	1.2905	1.1561	1.0471	1.2762	1.1492	1.0452	1.2489	1.1358	1.0415
0.3	1.5364	1.2791	1.1506	1.0456	1.2498	1.1363	1.0416	1.2222	1.1224	1.0377
	1.7221	1.3551	1.1866	1.0553	1.3383	1.1588	1.0532	1.3060	1.1636	1.0492
0.4	1.7090	1.3500	1.1842	1.0547	1.3320	1.1562	1.0526	1.2998	1.1606	1.0484
	1.8731	1.4111	1.2118	1.0619	1.3924	1.2035	1.0597	1.3565	1.1872	1.0555
0.5	1.8721	1.4107	1.2117	1.0618	1.3920	1.2033	1.0597	1.3561	1.1870	1.0554
	2.1486	1.5017	1.2507	1.0716	1.4810	1.2429	1.0695	1.4414	1.2251	1.0652
0.7	2.1656	1.5069	1.2529	1.0721	1.4869	1.2445	1.0700	1.4486	1.2282	1.0660
	2.4080	1.5995	1.2901	1.0810	1.5783	1.2818	1.0790	1.5377	1.2656	1.0752
1.0	2.5276	1.6070	1.2930	1.0817	1.5874	1.2853	1.0799	1.5495	1.2703	1.0763
	2.9386	1.7016	1.3287	1.0899	1.6823	1.3216	1.0883	1.6449	1.3076	1.0851
1.5	2.9712	1.7084	1.3312	1.0904	1.6909	1.3248	1.0890	1.6569	1.3122	1.0861
					$\rho_3 = 0.3$					
	1.2742	1.1544	1.0878	1.0276	1.1446	1.0820	1.0259	1.1251	1.0715	1.0227
0.1	1.2421	1.1387	1.0788	1.0250	1.1274	1.0728	1.0231	1.1041	1.0616	1.0197
	1.4923	1.2597	1.1412	1.0430	1.2421	1.1324	1.0406	1.2098	1.1161	1.0359
0.2	1.4729	1.2510	1.1369	1.0418	1.2330	1.1279	1.0393	1.1998	1.1110	1.0345
	1.7137	1.3519	1.1851	1.0549	1.3306	1.1752	1.0523	1.2911	1.1565	1.0472
0.3	1.6893	1.3423	1.1807	1.0537	1.3202	1.1703	1.0510	1.2794	1.1508	1.0457
	1.9010	1.4209	1.2161	1.0630	1.3971	1.2056	1.0603	1.3529	1.1855	1.0550
0.4	1.8890	1.4167	1.2143	1.0625	1.3925	1.2035	1.0597	1.3474	1.1830	1.0543
	2.0726	1.4781	1.2408	1.0692	1.4529	1.2300	1.0665	1.4059	1.2095	1.0613
0.5	2.0717	1.4778	1.2407	1.0691	1.4526	1.2299	1.0665	1.4054	1.2093	1.0612
	2.3733	1.5666	1.2771	1.0780	1.5406	1.2667	1.0755	1.4917	1.2465	1.0706
0.7	2.3883	1.5706	1.2787	1.0783	1.5454	1.2686	1.0759	1.4978	1.2491	1.0712
	2.7365	1.6573	1.3123	1.0862	1.6325	1.3029	1.0840	1.5853	1.2846	1.0797
1.0	2.7621	1.6631	1.3145	1.0867	1.6397	1.3056	1.0846	1.5951	1.2884	1.0806
	3.1726	1.7483	1.3455	1.0936	1.7269	1.3379	1.0919	1.6857	1.3229	1.0886
1.5	3.2003	1.7535	1.3473	1.0940	1.7337	1.3403	1.0925	1.6955	1.3265	1.0894

TABLE III — Component Ceiling Lighting. L_1/L_∞. L = Luminous Emittance; ρ = Reflectance. Subscripts: 1—Wall; 2—Ceiling; 3—Floor; Upper Entry—Square Room; Lower Entry—Infinite Hallway.

ρ_2	0.8				0.7			0.5		
ρ_1	0.8	0.5	0.3	0.1	0.5	0.3	0.1	0.5	0.3	0.1
k_r										
					$\rho_3 = 0.1$					
	0.4794	0.2777	0.1589	0.0506	0.2743	0.1573	0.0502	0.2676	0.1541	0.0494
0.1	0.4848	0.2842	0.1637	0.0525	0.2806	0.1620	0.0520	0.2736	0.1588	0.0512
	0.4817	0.2637	0.1461	0.0452	0.2600	0.1447	0.0450	0.2530	0.1419	0.0444
0.2	0.4859	0.2678	0.1489	0.0463	0.2640	0.1474	0.0460	0.2567	0.1446	0.0454
	0.4756	0.2454	0.1319	0.0398	0.2419	0.1307	0.0396	0.2350	0.1283	0.0392
0.3	0.4819	0.2507	0.1353	0.0410	0.2470	0.1340	0.0408	0.2398	0.1315	0.0404
	0.4704	0.2313	0.1215	0.0360	0.2279	0.1204	0.0359	0.2213	0.1183	0.0355
0.4	0.4739	0.2339	0.1231	0.0365	0.2304	0.1220	0.0364	0.2237	0.1198	0.0361
	0.4629	0.2179	0.1123	0.0329	0.2147	0.1113	0.0327	0.2115	0.1104	0.0326
0.5	0.4632	0.2181	0.1124	0.0328	0.2149	0.1115	0.0327	0.2086	0.1095	0.0324
	0.4434	0.1937	0.0968	0.0276	0.1909	0.0960	0.0276	0.1854	0.0946	0.0274
0.7	0.4375	0.1903	0.0949	0.0270	0.1876	0.0942	0.0270	0.1824	0.0928	0.0268
	0.4090	0.1637	0.0792	0.0221	0.1614	0.0787	0.0220	0.1571	0.0776	0.0219
1.0	0.3971	0.1578	0.0762	0.0213	0.1558	0.0757	0.0212	0.1519	0.0747	0.0211
	0.3527	0.1276	0.0598	0.0164	0.1262	0.0595	0.0163	0.1234	0.0588	0.0163
1.5	0.3380	0.1215	0.0568	0.0155	0.1202	0.0565	0.0155	0.1177	0.0559	0.0154
					$\rho_3 = 0.3$					
	0.6583	0.3731	0.2108	0.0664	0.3608	0.2046	0.0647	0.3384	0.1934	0.0615
0.1	0.6650	0.3810	0.2166	0.0686	0.3684	0.2103	0.0669	0.3455	0.1988	0.0637
	0.6384	0.3368	0.1830	0.0557	0.3269	0.1788	0.0547	0.3088	0.1709	0.0529
0.2	0.6431	0.3414	0.1861	0.0569	0.3313	0.1818	0.0559	0.3129	0.1738	0.0540
	0.6126	0.3020	0.1589	0.0471	0.2940	0.1558	0.0465	0.2792	0.1501	0.0453
0.3	0.6192	0.3075	0.1623	0.0483	0.2993	0.1592	0.0477	0.2842	0.1534	0.0464
	0.5907	0.2759	0.1417	0.0413	0.2692	0.1394	0.0409	0.2569	0.1351	0.0401
0.4	0.5942	0.2785	0.1432	0.0418	0.2718	0.1409	0.0414	0.2592	0.1365	0.0406
	0.5689	0.2536	0.1277	0.0367	0.2479	0.1259	0.0364	0.2373	0.1225	0.0358
0.5	0.5692	0.2538	0.1278	0.0367	0.2481	0.1260	0.0364	0.2375	0.1226	0.0358
	0.5266	0.2172	0.1063	0.0299	0.2131	0.1051	0.0297	0.2051	0.1028	0.0294
0.7	0.5211	0.2142	0.1046	0.0294	0.2101	0.1035	0.0293	0.2023	0.1012	0.0289
	0.4686	0.1774	0.0843	0.0233	0.1745	0.0836	0.0232	0.1691	0.0822	0.0230
1.0	0.4580	0.1724	0.0817	0.0225	0.1697	0.0811	0.0224	0.1645	0.0797	0.0223
	0.3899	0.1343	0.0620	0.0168	0.1326	0.0616	0.0168	0.1293	0.0609	0.0167
1.5	0.3772	0.1292	0.0595	0.0161	0.1276	0.0592	0.0161	0.1246	0.0585	0.0160

TABLE IV — Component Floor Lighting. L_3/L_∞. L = Luminous Emittance; ρ = Reflectance. Subscripts: 1—Wall; 2—Ceiling; 3—Floor; Upper Entry—Square Room; Lower Entry—Infinite Hallway.

ρ_2		0.8				0.7			0.5		
ρ_1	0.8	0.5	0.3	0.1	0.5	0.3	0.1	0.5	0.3	0.1
k_r										
					$\rho_3 = 0.1$					
0.1	0.7357	0.4263	0.2439	0.0777	0.3999	0.2294	0.0732	0.3493	0.2012	0.0645
	0.7419	0.4349	0.2506	0.0803	0.4081	0.2357	0.0757	0.3565	0.2069	0.0667
0.2	0.6979	0.3820	0.2117	0.0656	0.3601	0.2004	0.0623	0.3179	0.1783	0.0558
	0.7015	0.3866	0.2150	0.0668	0.3644	0.2035	0.0635	0.3219	0.1812	0.0569
0.3	0.6581	0.3396	0.1826	0.0551	0.3215	0.1737	0.0527	0.2867	0.1564	0.0478
	0.6626	0.3447	0.1860	0.0564	0.3264	0.1771	0.0539	0.2913	0.1597	0.0490
0.4	0.6239	0.3068	0.1612	0.0478	0.2917	0.1541	0.0460	0.2626	0.1404	0.0422
	0.6260	0.3091	0.1627	0.0483	0.2938	0.1556	0.0464	0.2647	0.1418	0.0427
0.5	0.5920	0.2787	0.1436	0.0420	0.2660	0.1380	0.0405	0.2417	0.1269	0.0376
	0.5922	0.2789	0.1437	0.0420	0.2661	0.1380	0.0405	0.2418	0.1270	0.0376
0.7	0.5351	0.2338	0.1168	0.0334	0.2247	0.1131	0.0324	0.2073	0.1057	0.0306
	0.5326	0.2316	0.1155	0.0330	0.2225	0.1117	0.0320	0.2050	0.1043	0.0302
1.0	0.4651	0.1861	0.0900	0.0252	0.1804	0.0880	0.0247	0.1695	0.0837	0.0237
	0.4612	0.1832	0.0885	0.0247	0.1773	0.0862	0.0241	0.1659	0.0816	0.0230
1.5	0.3797	0.1374	0.0643	0.0176	0.1345	0.0634	0.0174	0.1287	0.0614	0.0170
	0.3757	0.1350	0.0631	0.0172	0.1317	0.0619	0.0170	0.1252	0.0595	0.0164
					$\rho_3 = 0.3$					
0.1	0.8764	0.4967	0.2806	0.0883	0.4364	0.2588	0.0818	0.3832	0.2190	0.0697
	0.8837	0.5064	0.2879	0.0912	0.4654	0.2657	0.0845	0.3910	0.2250	0.0720
0.2	0.8198	0.4325	0.2351	0.0716	0.4013	0.2195	0.0672	0.3439	0.1904	0.0589
	0.8240	0.4374	0.2385	0.0729	0.4059	0.2228	0.0684	0.3481	0.1934	0.0600
0.3	0.7639	0.3767	0.1981	0.0588	0.3522	0.1866	0.0557	0.3069	0.1649	0.0498
	0.7690	0.3810	0.2016	0.0600	0.3572	0.1900	0.0569	0.3117	0.1682	0.0510
0.4	0.7167	0.3348	0.1719	0.0501	0.3122	0.1632	0.0478	0.2787	0.1466	0.0434
	0.7191	0.3370	0.1733	0.0506	0.3174	0.1646	0.0483	0.2810	0.1480	0.0440
0.5	0.6739	0.3004	0.1513	0.0434	0.2845	0.1445	0.0418	0.2548	0.1316	0.0385
	0.6740	0.3005	0.1514	0.0435	0.2847	0.1446	0.0418	0.2550	0.1317	0.0385
0.7	0.6000	0.2475	0.1211	0.0341	0.2368	0.1168	0.0331	0.2166	0.1086	0.0311
	0.5973	0.2455	0.1199	0.0337	0.2347	0.1156	0.0327	0.2142	0.1071	0.0306
1.0	0.5128	0.1941	0.0922	0.0254	0.1877	0.0899	0.0249	0.1754	0.0853	0.0239
	0.5085	0.1914	0.0907	0.0250	0.1846	0.0882	0.0244	0.1717	0.0832	0.0233
1.5	0.4107	0.1415	0.0653	0.0177	0.1383	0.0642	0.0175	0.1321	0.0622	0.0171
	0.4064	0.1392	0.0642	0.0174	0.1355	0.0629	0.0171	0.1285	0.0603	0.0165

TABLE V — Component Wall Lighting, $L_2/L_{\infty 3}$. L = Luminous Emittance; ρ = Reflectance. Subscripts: 1—Wall; 2—Ceiling; 3—Floor; Upper Entry—Square Room; Lower Entry—Infinite Hallway.

ρ_2		0.8				0.7			0.5		
ρ_1	0.8	0.5	0.3	0.1	0.5	0.3	0.1	0.5	0.3	0.1
k_r										
					$\rho_3 = 0.1$					
0.1	0.1918	0.1778	0.1695	0.1620	0.1536	0.1468	0.1406	0.1070	0.1028	0.0988
	0.1939	0.1819	0.1747	0.1680	0.1571	0.1512	0.1458	0.1094	0.1058	0.1024
0.2	0.3854	0.3375	0.3117	0.2896	0.2912	0.2701	0.2518	0.2024	0.1892	0.1776
	0.3887	0.3428	0.3178	0.2961	0.2957	0.2752	0.2574	0.2054	0.1927	0.1815
0.3	0.5707	0.4713	0.4222	0.3824	0.4063	0.3660	0.3328	0.2821	0.2566	0.2353
	0.5782	0.4814	0.4330	0.3935	0.4150	0.3753	0.3425	0.2878	0.2630	0.2421
0.4	0.7526	0.5922	0.5185	0.4612	0.5105	0.4496	0.4018	0.3541	0.3154	0.2845
	0.7582	0.5990	0.5254	0.4679	0.5162	0.4556	0.4077	0.3579	0.3196	0.2887
0.5	0.9258	0.6974	0.5989	0.5248	0.6011	0.5195	0.4575	0.4169	0.3648	0.3243
	0.9263	0.6980	0.5996	0.5254	0.6017	0.5201	0.4580	0.4172	0.3652	0.3247
0.7	1.2417	0.8679	0.7228	0.6193	0.7482	0.6275	0.5403	0.5192	0.4413	0.3837
	1.2250	0.8525	0.7088	0.6066	0.7353	0.6154	0.5291	0.5106	0.4329	0.3757
1.0	1.6359	1.0475	0.8449	0.7080	0.9040	0.7342	0.6181	0.6287	0.5174	0.4396
	1.5883	1.0098	0.8125	0.6797	0.8723	0.7063	0.5934	0.6070	0.4981	0.4220
1.5	2.1163	1.2254	0.9569	0.7849	1.0599	0.8327	0.6857	0.7401	0.5883	0.4882
	2.0278	1.1659	0.9085	0.7442	1.0095	0.7909	0.6502	0.7062	0.5589	0.4629
					$\rho_3 = 0.3$					
0.1	0.2633	0.2388	0.2248	0.2124	0.2020	0.1910	0.1811	0.1354	0.1289	0.1230
	0.2660	0.2439	0.2310	0.2195	0.2063	0.1963	0.1872	0.1382	0.1325	0.1273
0.2	0.5107	0.4311	0.3906	0.3570	0.3661	0.3338	0.3067	0.2470	0.2279	0.2115
	0.5145	0.4370	0.3971	0.3639	0.3711	0.3394	0.3128	0.2503	0.2318	0.2158
0.3	0.7351	0.5799	0.5083	0.4525	0.4940	0.4363	0.3907	0.3351	0.3001	0.2718
	0.7430	0.5906	0.5193	0.4635	0.5029	0.4458	0.4003	0.3410	0.3068	0.2787
0.4	0.9451	0.7064	0.6046	0.5285	0.6032	0.5205	0.4578	0.4110	0.3601	0.3205
	0.9508	0.7131	0.6112	0.5348	0.6089	0.5262	0.4633	0.4147	0.3641	0.3245
0.5	1.1378	0.8114	0.6811	0.5869	0.6942	0.5877	0.5095	0.4747	0.4084	0.3583
	1.1384	0.8120	0.6817	0.5874	0.6947	0.5882	0.5100	0.4750	0.4087	0.3587
0.7	1.4746	0.9733	0.7934	0.6697	0.8352	0.6867	0.5830	0.5744	0.4800	0.4122
	1.4591	0.9596	0.7812	0.6588	0.8236	0.6760	0.5734	0.5666	0.4725	0.4052
1.0	1.8744	1.1352	0.8989	0.7440	0.9773	0.7799	0.6489	0.6762	0.5479	0.4606
	1.8321	1.1032	0.8719	0.7208	0.9501	0.7565	0.6284	0.6579	0.5314	0.4457
1.5	2.3393	1.2891	0.9921	0.8064	1.1137	0.8629	0.7024	0.7760	0.6090	0.5011
	2.2635	1.2402	0.9530	0.7738	1.0721	0.8288	0.6756	0.7477	0.5850	0.4804

TABLE VI — Component Ceiling Lighting, L_2/L_{20}. L = Luminous Emittance; ρ = Reflectance. Subscripts: 1—Wall; 2—Ceiling; 3—Floor; Upper Entry—Square Room; Lower Entry—Infinite Hallway.

ρ_2	0.8				0.7			0.5		
ρ_1	0.8	0.5	0.3	0.1	0.5	0.3	0.1	0.5	0.3	0.1
k_r										
					$\rho_3 = 0.1$					
0.1	1.1339	1.1019	1.0831	1.0659	1.0881	1.0719	1.0572	1.0614	1.0504	1.0402
	1.1367	1.1037	1.0838	1.0655	1.0895	1.0726	1.0568	1.0624	1.0508	1.0399
0.2	1.1737	1.1128	1.0799	1.0517	1.0973	1.0692	1.0450	1.0676	1.0485	1.0317
	1.1772	1.1147	1.0807	1.0513	1.0990	1.0699	1.0446	1.0688	1.0490	1.0315
0.3	1.2013	1.1173	1.0759	1.0422	1.1012	1.0657	1.0367	1.0702	1.0461	1.0260
	1.2077	1.1207	1.0773	1.0417	1.1040	1.0669	1.0363	1.0721	1.0469	1.0257
0.4	1.2251	1.1206	1.0726	1.0352	1.1040	1.0630	1.0307	1.0721	1.0442	1.0218
	1.2291	1.1226	1.0735	1.0350	1.1057	1.0637	1.0305	1.0733	1.0447	1.0216
0.5	1.2427	1.1217	1.0695	1.0302	1.1049	1.0603	1.0263	1.0727	1.0423	1.0187
	1.2431	1.1219	1.0695	1.0302	1.1050	1.0603	1.0263	1.0728	1.0424	1.0186
0.7	1.2638	1.1194	1.0634	1.0234	1.1030	1.0550	1.0204	1.0714	1.0387	1.0145
	1.2558	1.1159	1.0620	1.0236	1.1000	1.0538	1.0206	1.0695	1.0379	1.0146
1.0	1.2711	1.1104	1.0550	1.0177	1.0952	1.0479	1.0155	1.0663	1.0337	1.0110
	1.2540	1.1036	1.0523	1.0178	1.0895	1.0455	1.0156	1.0623	1.0321	1.0111
1.5	1.2550	1.0929	1.0440	1.0128	1.0804	1.0383	1.0111	1.0561	1.0271	1.0079
	1.2328	1.0850	1.0409	1.0127	1.0736	1.0356	1.0111	1.0515	1.0252	1.0079
					$\rho_3 = 0.3$					
0.1	1.3324	1.2735	1.2399	1.2101	1.2314	1.2038	1.1791	1.1550	1.1376	1.1217
	1.3347	1.2739	1.2387	1.2070	1.2317	1.2028	1.1766	1.1553	1.1369	1.1201
0.2	1.3454	1.2422	1.1896	1.1460	1.2057	1.1621	1.1255	1.1388	1.1106	1.0865
	1.3482	1.2428	1.1886	1.1435	1.2062	1.1612	1.1233	1.1391	1.1101	1.0851
0.3	1.3507	1.2174	1.1560	1.1081	1.1852	1.1339	1.0933	1.1257	1.0921	1.0649
	1.3557	1.2186	1.1547	1.1046	1.1861	1.1328	1.0903	1.1263	1.0914	1.0629
0.4	1.3546	1.1981	1.1314	1.0815	1.1692	1.1131	1.0706	1.1153	1.0782	1.0494
	1.3578	1.1989	1.1308	1.0797	1.1698	1.1126	1.0691	1.1157	1.0779	1.0483
0.5	1.3554	1.1823	1.1132	1.0632	1.1560	1.0977	1.0549	1.1067	1.0679	1.0386
	1.3557	1.1824	1.1132	1.0631	1.1560	1.0977	1.0548	1.1067	1.0678	1.0385
0.7	1.3499	1.1577	1.0887	1.0413	1.1353	1.0768	1.0359	1.0930	1.0537	1.0254
	1.3437	1.1561	1.0892	1.0432	1.1340	1.0772	1.0376	1.0922	1.0539	1.0266
1.0	1.3307	1.1312	1.0674	1.0256	1.1129	1.0585	1.0223	1.0781	1.0411	1.0159
	1.3174	1.1279	1.0678	1.0285	1.1101	1.0588	1.0248	1.0763	1.0413	1.0176
1.5	1.2905	1.1019	1.0487	1.0153	1.0880	1.0423	1.0134	1.0614	1.0299	1.0095
	1.2732	1.0977	1.0485	1.0178	1.0845	1.0422	1.0155	1.0589	1.0298	1.0110

TABLE VII — Component Floor Lighting, L_2/L_{30}. L = Luminous Emittance; ρ = Reflectance. Subscripts: 1—Wall; 2—Ceiling; 3—Floor; Upper Entry—Square Room; Lower Entry—Infinite Hallway.

ρ_3	0.8				0.7			0.5		
ρ_1	0.8	0.5	0.3	0.1	0.5	0.3	0.1	0.5	0.3	0.1
k_r										
					$\rho_3 = 0.1$					
0.1	0.8165	0.7675	0.7386	0.7122	0.6631	0.6396	0.6181	0.4620	0.4477	0.4344
	0.8154	0.7658	0.7344	0.7063	0.6606	0.6360	0.6130	0.4601	0.4450	0.4309
0.2	0.7646	0.6763	0.6287	0.5878	0.5835	0.5447	0.5110	0.4055	0.3815	0.3604
	0.7631	0.6730	0.6238	0.5814	0.5805	0.5404	0.5054	0.4033	0.3784	0.3565
0.3	0.7173	0.6010	0.5437	0.4971	0.5183	0.4712	0.4327	0.3598	0.3304	0.3059
	0.7142	0.5946	0.5349	0.4861	0.5126	0.4636	0.4231	0.3556	0.3249	0.2991
0.4	0.6716	0.5330	0.4694	0.4199	0.4595	0.4071	0.3658	0.3188	0.2856	0.2590
	0.6695	0.5289	0.4639	0.4132	0.4558	0.4022	0.3600	0.3160	0.2821	0.2549
0.5	0.6292	0.4744	0.4076	0.3573	0.4089	0.3536	0.3115	0.2836	0.2483	0.2209
	0.6290	0.4740	0.4071	0.3568	0.4085	0.3531	0.3110	0.2835	0.2479	0.2205
0.7	0.5543	0.3802	0.3126	0.2644	0.3278	0.2714	0.2306	0.2274	0.1908	0.1638
	0.5598	0.3895	0.3239	0.2771	0.3360	0.2812	0.2418	0.2353	0.1978	0.1717
1.0	0.4651	0.2824	0.2195	0.1770	0.2437	0.1908	0.1545	0.1695	0.1344	0.1099
	0.4794	0.3049	0.2452	0.2052	0.2633	0.2132	0.1791	0.1834	0.1503	0.1274
1.5	0.3619	0.1874	0.1349	0.1011	0.1621	0.1173	0.0884	0.1132	0.0829	0.0629
	0.3865	0.2225	0.1731	0.1419	0.1924	0.1508	0.1239	0.1346	0.1066	0.0882
					$\rho_3 = 0.3$					
0.1	0.9726	0.8942	0.8495	0.8098	0.7565	0.7217	0.6904	0.5069	0.4871	0.4691
	0.9712	0.8904	0.8436	0.8015	0.7533	0.7168	0.6836	0.5047	0.4839	0.4649
0.2	0.8982	0.7657	0.6981	0.6421	0.6503	0.5967	0.5518	0.4387	0.4074	0.3805
	0.8964	0.7614	0.6919	0.6340	0.6466	0.5915	0.5450	0.4361	0.4039	0.3760
0.3	0.8326	0.6665	0.5899	0.5302	0.5678	0.5063	0.4577	0.3852	0.3483	0.3184
	0.8289	0.6587	0.5794	0.5171	0.5610	0.4973	0.4466	0.3805	0.3422	0.3110
0.4	0.7715	0.5817	0.5007	0.4401	0.4967	0.4310	0.3812	0.3384	0.2982	0.2669
	0.7690	0.5767	0.4943	0.4325	0.4924	0.4256	0.3747	0.3354	0.2945	0.2625
0.5	0.7162	0.5112	0.4294	0.3702	0.4373	0.3704	0.3213	0.2991	0.2574	0.2260
	0.7160	0.5107	0.4288	0.3695	0.4369	0.3699	0.3208	0.2988	0.2571	0.2256
0.7	0.6216	0.4026	0.3240	0.2700	0.3455	0.2804	0.2350	0.2376	0.1960	0.1662
	0.6277	0.4128	0.3361	0.2834	0.3543	0.2909	0.2467	0.2438	0.2033	0.1743
1.0	0.5128	0.2945	0.2247	0.1790	0.2535	0.1950	0.1561	0.1754	0.1370	0.1108
	0.5287	0.3183	0.2516	0.2080	0.2742	0.2183	0.1813	0.1899	0.1534	0.1286
1.5	0.3915	0.1930	0.1368	0.1017	0.1667	0.1190	0.0883	0.1162	0.0840	0.0632
	0.4181	0.2291	0.1760	0.1429	0.1980	0.1530	0.1248	0.1381	0.1081	0.0887

TABLE VIII — Component Wall Lighting, L_3/L_{∞}. L = Luminous Emittance; ρ = Reflectance. Subscripts: 1—Wall; 2—Ceiling; 3—Floor; Upper Entry—Square Room; Lower Entry—Infinite Hallway.

ρ_2	0.8			0.7			0.5		
ρ_1	0.8	0.5	0.3	0.1	0.5	0.3	0.1	0.5	0.3	0.1
k_r										
					$\rho_3 = 0.1$					
	0.0368	0.0341	0.0325	0.0310	0.0320	0.0305	0.0293	0.0279	0.0268	0.0258
0.1	0.0371	0.0348	0.0334	0.0321	0.0326	0.0314	0.0303	0.0285	0.0275	0.0267
	0.0698	0.0611	0.0564	0.0524	0.0576	0.0534	0.0498	0.0509	0.0475	0.0446
0.2	0.0701	0.0619	0.0573	0.0534	0.0583	0.0543	0.0508	0.0515	0.0483	0.0456
	0.0987	0.0815	0.0730	0.0661	0.0771	0.0695	0.0631	0.0689	0.0625	0.0574
0.3	0.0993	0.0827	0.0744	0.0676	0.0783	0.0708	0.0647	0.0699	0.0639	0.0588
	0.1248	0.0982	0.0860	0.0765	0.0933	0.0822	0.0734	0.0840	0.0749	0.0675
0.4	0.1252	0.0989	0.0867	0.0772	0.0940	0.0830	0.0743	0.0847	0.0756	0.0683
	0.1480	0.1115	0.0957	0.0839	0.1064	0.0919	0.0810	0.1015	0.0882	0.0780
0.5	0.1480	0.1115	0.0958	0.0840	0.1064	0.0920	0.0810	0.0967	0.0846	0.0752
	0.1872	0.1309	0.1090	0.0934	0.1258	0.1055	0.0908	0.1160	0.0986	0.0858
0.7	0.1864	0.1297	0.1079	0.0922	0.1246	0.1043	0.0897	0.1148	0.0973	0.0845
	0.2326	0.1489	0.1201	0.1006	0.1443	0.1172	0.0987	0.1356	0.1116	0.0948
1.0	0.2305	0.1466	0.1180	0.0987	0.1419	0.1149	0.0965	0.1327	0.1088	0.0921
	0.2848	0.1649	0.1288	0.1056	0.1614	0.1268	0.1044	0.1545	0.1228	0.1019
1.5	0.2818	0.1620	0.1263	0.1034	0.1580	0.1238	0.1018	0.1502	0.1190	0.0985
					$\rho_3 = 0.3$					
	0.1315	0.1192	0.1122	0.1060	0.1095	0.1035	0.0982	0.0920	0.0876	0.0836
0.1	0.1326	0.1215	0.1151	0.1094	0.1117	0.1062	0.1014	0.0939	0.0900	0.0864
	0.2459	0.2076	0.1881	0.1719	0.1926	0.1756	0.1613	0.1651	0.1523	0.1413
0.2	0.2472	0.2100	0.1908	0.1748	0.1948	0.1782	0.1642	0.1671	0.1547	0.1441
	0.3438	0.2712	0.2377	0.2116	0.2536	0.2239	0.2005	0.2209	0.1979	0.1792
0.3	0.3461	0.2750	0.2419	0.2159	0.2572	0.2280	0.2048	0.2244	0.2019	0.1834
	0.4300	0.3214	0.2751	0.2404	0.3026	0.2611	0.2297	0.2676	0.2345	0.2087
0.4	0.4314	0.3236	0.2773	0.2427	0.3048	0.2634	0.2319	0.2697	0.2368	0.2111
	0.5054	0.3604	0.3026	0.2607	0.3414	0.2890	0.2506	0.3058	0.2631	0.2309
0.5	0.5055	0.3606	0.3027	0.2609	0.3416	0.2892	0.2508	0.3060	0.2633	0.2311
	0.6300	0.4158	0.3390	0.2861	0.3978	0.3271	0.2777	0.3638	0.3040	0.2611
0.7	0.6272	0.4124	0.3358	0.2832	0.3942	0.3236	0.2744	0.3598	0.3000	0.2573
	0.7692	0.4659	0.3689	0.3053	0.4504	0.3595	0.2991	0.4211	0.3412	0.2868
1.0	0.7628	0.4593	0.3630	0.3000	0.4431	0.3528	0.2931	0.4122	0.3329	0.2792
	0.9241	0.5093	0.3919	0.3186	0.4977	0.3856	0.3147	0.4756	0.3732	0.3071
1.5	0.9145	0.5011	0.3850	0.3126	0.4879	0.3772	0.3074	0.4625	0.3618	0.2972

TABLE IX — Component Ceiling Lighting, L_3/L_{∞}. L = Luminous Emittance; ρ = Reflectance. Subscripts: 1—Wall; 2—Ceiling; 3—Floor; Upper Entry—Square Room; Lower Entry—Infinite Hallway.

ρ_2	0.8				0.7			0.5		
ρ_1	0.8	0.5	0.3	0.1	0.5	0.3	0.1	0.5	0.3	0.1
k_r										
						$\rho_3 = 0.1$				
	0.1021	0.0959	0.0923	0.0890	0.0947	0.0913	0.0883	0.0924	0.0895	0.0869
0.1	0.1019	0.0956	0.0918	0.0883	0.0944	0.0909	0.0876	0.0920	0.0890	0.0862
	0.0956	0.0845	0.0786	0.0735	0.0834	0.0778	0.0730	0.0811	0.0763	0.0721
0.2	0.0951	0.0841	0.0780	0.0727	0.0829	0.0772	0.0722	0.0807	0.0757	0.0713
	0.0896	0.0751	0.0680	0.0621	0.0740	0.0673	0.0618	0.0720	0.0660	0.0612
0.3	0.0893	0.0743	0.0669	0.0608	0.0732	0.0662	0.0604	0.0711	0.0650	0.0598
	0.0840	0.0666	0.0587	0.0525	0.0656	0.0581	0.0522	0.0637	0.0571	0.0518
0.4	0.0837	0.0661	0.0580	0.0516	0.0651	0.0574	0.0514	0.0632	0.0564	0.0510
	0.0787	0.0593	0.0510	0.0447	0.0584	0.0505	0.0445	0.0567	0.0497	0.0441
0.5	0.0786	0.0592	0.0509	0.0446	0.0583	0.0504	0.0444	0.0567	0.0496	0.0441
	0.0690	0.0475	0.0390	0.0330	0.0468	0.0388	0.0330	0.0454	0.0382	0.0328
0.7	0.0700	0.0487	0.0405	0.0346	0.0480	0.0402	0.0345	0.0466	0.0396	0.0343
	0.0571	0.0353	0.0274	0.0221	0.0348	0.0273	0.0220	0.0339	0.0269	0.0220
1.0	0.0599	0.0381	0.0307	0.0256	0.0377	0.0304	0.0256	0.0367	0.0301	0.0255
	0.0452	0.0234	0.0169	0.0126	0.0232	0.0168	0.0126	0.0226	0.0166	0.0126
1.5	0.0483	0.0278	0.0215	0.0177	0.0275	0.0215	0.0177	0.0260	0.0213	0.0176
						$\rho_3 = 0.3$				
	0.3647	0.3353	0.3186	0.3037	0.3242	0.3093	0.2959	0.3041	0.2923	0.2815
0.1	0.3642	0.3339	0.3164	0.3006	0.3229	0.3072	0.2930	0.3028	0.2904	0.2789
	0.3368	0.2871	0.2618	0.2408	0.2787	0.2557	0.2365	0.2632	0.2444	0.2283
0.2	0.3362	0.2856	0.2595	0.2378	0.2771	0.2535	0.2336	0.2617	0.2423	0.2256
	0.3122	0.2499	0.2212	0.1988	0.2433	0.2170	0.1961	0.2311	0.2090	0.1911
0.3	0.3109	0.2470	0.2173	0.1939	0.2404	0.2131	0.1914	0.2283	0.2053	0.1866
	0.2893	0.2181	0.1878	0.1650	0.2129	0.1847	0.1634	0.2030	0.1789	0.1602
0.4	0.2884	0.2163	0.1854	0.1622	0.2110	0.1824	0.1606	0.2013	0.1767	0.1545
	0.2686	0.1917	0.1610	0.1388	0.1874	0.1588	0.1377	0.1794	0.1545	0.1356
0.5	0.2685	0.1915	0.1608	0.1386	0.1873	0.1585	0.1375	0.1793	0.1543	0.1354
	0.2331	0.1510	0.1215	0.1012	0.1481	0.1202	0.1007	0.1425	0.1176	0.0997
0.7	0.2354	0.1548	0.1260	0.1063	0.1519	0.1247	0.1057	0.1463	0.1220	0.1046
	0.1923	0.1104	0.0843	0.0671	0.1086	0.0836	0.0669	0.1052	0.0822	0.0665
1.0	0.1983	0.1194	0.0944	0.0780	0.1175	0.0936	0.0777	0.1139	0.0920	0.0772
	0.1468	0.0724	0.0513	0.0381	0.0715	0.0510	0.0381	0.0697	0.0504	0.0380
1.5	0.1568	0.0859	0.0660	0.0536	0.0849	0.0656	0.0535	0.0829	0.0648	0.0532

TABLE X — Component Floor Lighting, L_3/L_{∞}. L = Luminous Emittance; ρ = Reflectance. Subscripts: 1—Wall; 2—Ceiling; 3—Floor; Upper Entry—Square Room; Lower Entry—Infinite Hallway.

ρ_2	0.8				0.7			0.5		
ρ_1	0.8	0.5	0.3	0.1	0.5	0.3	0.1	0.5	0.3	0.1
k_r										
					$\rho_3 = 0.1$					
	1.0803	1.0708	1.0653	1.0602	1.0618	1.0569	1.0524	1.0443	1.0405	1.0370
0.1	1.0802	1.0705	1.0647	1.0594	1.0615	1.0564	1.0516	1.0441	1.0402	1.0365
	1.0744	1.0584	1.0497	1.0423	1.0513	1.0436	1.0370	1.0378	1.0317	1.0264
0.2	1.0743	1.0580	1.0491	1.0415	1.0510	1.0431	1.0363	1.0377	1.0315	1.0260
	1.0692	1.0491	1.0392	1.0311	1.0435	1.0346	1.0273	1.0329	1.0257	1.0198
0.3	1.0692	1.0486	1.0384	1.0300	1.0431	1.0339	1.0263	1.0328	1.0253	1.0190
	1.0647	1.0417	1.0312	1.0230	1.0374	1.0278	1.0202	1.0290	1.0211	1.0148
0.4	1.0647	1.0415	1.0307	1.0224	1.0371	1.0274	1.0197	1.0289	1.0209	1.0145
	1.0607	1.0360	1.0253	1.0173	1.0325	1.0227	1.0153	1.0259	1.0177	1.0114
0.5	1.0607	1.0360	1.0253	1.0172	1.0325	1.0227	1.0153	1.0259	1.0177	1.0113
	1.0540	1.0278	1.0176	1.0104	1.0256	1.0161	1.0093	1.0213	1.0131	1.0071
0.7	1.0541	1.0282	1.0182	1.0111	1.0259	1.0166	1.0099	1.0214	1.0134	1.0075
	1.0465	1.0205	1.0116	1.0056	1.0193	1.0108	1.0051	1.0169	1.0093	1.0041
1.0	1.0465	1.0212	1.0125	1.0067	1.0198	1.0116	1.0060	1.0170	1.0098	1.0048
	1.0377	1.0143	1.0072	1.0027	1.0138	1.0069	1.0025	1.0127	1.0064	1.0022
1.5	1.0378	1.0149	1.0081	1.0037	1.0142	1.0076	1.0034	1.0127	1.0067	1.0028
					$\rho_3 = 0.3$					
	1.2868	1.2476	1.2253	1.2055	1.2114	1.1925	1.1755	1.1456	1.1322	1.1200
0.1	1.2866	1.2464	1.2230	1.2020	1.2104	1.1906	1.1727	1.1453	1.1312	1.1182
	1.2621	1.1982	1.1657	1.1388	1.1715	1.1434	1.1198	1.1227	1.1017	1.0838
0.2	1.2619	1.1970	1.1636	1.1358	1.1707	1.1417	1.1173	1.1223	1.1008	1.0822
	1.2411	1.1635	1.1276	1.0997	1.1432	1.1116	1.0867	1.1057	1.0814	1.0617
0.3	1.2409	1.1617	1.1246	1.0956	1.1418	1.1092	1.0833	1.1032	1.0800	1.0595
	1.2230	1.1367	1.0998	1.0723	1.1212	1.0883	1.0633	1.0924	1.0662	1.0458
0.4	1.2229	1.1357	1.0983	1.0702	1.1205	1.0870	1.0617	1.0821	1.0655	1.0447
	1.2074	1.1164	1.0800	1.0537	1.1044	1.0715	1.0473	1.0820	1.0551	1.0349
0.5	1.2225	1.0461	1.0247	1.0113	1.0437	1.0711	1.0472	1.0819	1.0551	1.0348
	1.1820	1.0884	1.0548	1.0317	1.0810	1.0500	1.0283	1.0669	1.0405	1.0215
0.7	1.1821	1.0897	1.0568	1.0341	1.0819	1.0515	1.0304	1.0671	1.0414	1.0230
	1.1538	1.0643	1.0356	1.0168	1.0603	1.0333	1.0153	1.0526	1.0287	1.0124
1.0	1.1540	1.0664	1.0386	1.0205	1.0617	1.0357	1.0184	1.0528	1.0299	1.0144
	1.1226	1.0441	1.0220	1.0081	1.0424	1.0211	1.0076	1.0391	1.0194	1.0066
1.5	1.1225	1.0461	1.0247	1.0113	1.0437	1.0233	1.0104	1.0390	1.0204	1.0085

$$E_1(1.0) = (0.706)(0.533) + (0.147)(1.395) + (0.147)(0.368) = 0.635 \quad (7)$$

and

$$L_1(1.0) = \rho_1 E_1(1.0) = (0.8)(0.635) = 0.508. \quad (8)$$

The shape moduli used in the above numerical example were calculated using the relationship for an infinite strip as viewed from a differential surface element. This computation is greatly facilitated by using a lune or infinite-strip shape modulus protractor and a scaled elevation sectional view of the room in the manner outlined by Centeno and Zagustin.[8]

In Table XIII the detailed distribution of luminous emittance at the wall of the infinite hallway is reported as computed via Equation 6. Note that the truncation effect causes errors near ten per cent at the extreme top and bottom of the wall but the error at the center is quite small.

TABLE XI—Comparison of Luminous Emittance Ratios for Square Rooms and Infinite Hallways.

$k_r = 1.0$; $\rho_1 = 0.5$; $\rho_2 = 0.7$; $\rho_3 = 0.3$.

(a) Square Room
(b) Infinite Hallway
(c) Interflectance Value
(d) Per Cent Difference Between (a) and (b) Based on (a).
(e) Per Cent Difference Between (a) and (c) Based on (a).

	(a)	1.633		(a)	0.175		(a)	0.188
L_1/L_{01}	(b)	1.640	L_1/L_{02}	(b)	0.170	L_1/L_{03}	(b)	0.185
	(c)	1.652		(c)	0.170		(c)	0.175
	(d)	+0.4		(d)	−2.9		(d)	−1.6
	(e)	+1.2		(e)	−2.9		(e)	−6.9
	(a)	0.977		(a)	1.113		(a)	0.254
L_2/L_{01}	(b)	0.950	L_2/L_{02}	(b)	1.110	L_2/L_{03}	(b)	0.274
	(c)	1.035		(c)	1.144		(c)	0.199
	(d)	−2.7		(d)	−0.3		(d)	+7.9
	(e)	+5.9		(e)	+2.7		(e)	−21.6
	(a)	0.450		(a)	0.109		(a)	1.060
L_3/L_{01}	(b)	0.443	L_3/L_{02}	(b)	0.118	L_3/L_{03}	(b)	1.062
	(c)	0.457		(c)	0.085		(c)	1.066
	(d)	−1.6		(d)	+8.3		(d)	+0.2
	(e)	+1.6		(e)	−20.3		(e)	+0.6

TABLE XII — Comparison of Luminous Emittance Ratios for Square Rooms and Infinite Hallways.

$k_r = 1.0$; $\rho_1 = 0.3$; $\rho_2 = 0.5$; $\rho_3 = 0.1$.

(a) Square Room
(b) Infinite Hallway
(c) Interflectance Value
(d) Per Cent Difference Between (a) and (b) Based on (a)
(e) Per Cent Difference Between (a) and (c) Based on (a)

	(a) 1.266		(a) 0.078		(a) 0.084
L_1/L_{01}	(b) 1.270	L_1/L_{02}	(b) 0.075	L_1/L_{03}	(b) 0.082
	(c) 1.276		(c) 0.074		(c) 0.077
	(d) +0.3		(d) −3.8		(d) −2.4
	(e) +9.7		(e) −5.1		(e) −8.3
	(a) 0.517		(a) 1.034		(a) 0.134
L_2/L_{01}	(b) 0.498	L_2/L_{02}	(b) 1.032	L_2/L_{03}	(b) 0.150
	(c) 0.554		(c) 1.047		(c) 0.098
	(d) −3.7		(d) −0.2		(d) +11.9
	(e) +7.2		(e) +1.3		(e) −26.9
	(a) 0.112		(a) 0.027		(a) 1.009
L_3/L_{01}	(b) 0.109	L_3/L_{02}	(b) 0.030	L_3/L_{03}	(b) 1.010
	(c) 0.115		(c) 0.020		(c) 1.010
	(d) −2.7		(d) +11.1		(d) +0.1
	(e) +2.7		(e) −25.9		(e) +0.1

More accurate values of the average floor and ceiling emittance may be computed using the detailed distribution of wall emittance and an expression similar to Equation 6, that is, a revised illumination at the floor and ceiling is computed as the sum of the products of the shape moduli and the associated luminous emittances. The values of L_2 and L_3 computed by this first iteration are shown in Table XIII to have errors less than one per cent. Similarly, a second distribution at the wall based on the revised luminous emittances at the floor and ceiling and a four-surface representation of the wall is reported in Table XIII. The exact values reported in Table XIII were obtained from a recent paper by Spencer.[2]

Because the luminous transfer in square and long rooms of equal domance has been demonstrated to be equivalent within reasonable tolerance, calulations of detailed illumination distributions in finite rooms can be based on the performance of the equivalent infinitely long hallway. The height to width ratio of the equivalent infinite hallway is given by the relationship

$$(h/w)_{EQ} = 2.0\ k_r \qquad (9)$$

where:

h = height of equivalent infinite hallway
w = width of equivalent infinite hallway
k_r = domance of finite room

For example, a cubical room with a height to width ratio of 1.0 is represented by an infinitely long hallway of $(h/w)_{EQ}$ equal to 2.0. By this process a three-dimensional space is transformed to an equivalent two-dimensional space. The illumination at any surface element in a two-dimensional room or hallway can be obtained quickly by the lune protractor of Centano and Zagustin. Briefly, the shape moduli for two-dimensional spaces are much more easily obtained than those for three-dimensional spaces. Note that by this technique the vertical dimension of a finite room is exaggerated or expanded by Equation 9 to match the vertical dimension of the equivalent infinite hallway.

TABLE XIII — Exact and Approximate Distributions of Light in an Infinitely Long Hallway.

$k_r = 1.0$; Room Height = 2.0; Room Width = 1.0.
$\rho_2 = \rho_3 = 0.8$; $\rho_3 = 0.5$, Ceiling Lighting;
S = Relative Distance from Ceiling.

S		Exact	Three-Surface Approximation	Per Cent Error	First Iteration	Per Cent Error
0.0	$L_1(S)/L_{00}$	0.845	0.765	−9.5	0.809	−4.3
0.2	$L_1(S)/L_{00}$	0.762	0.694	−8.9	0.738	−3.2
0.4	$L_1(S)/L_{00}$	0.685	0.633	−7.6	0.669	−2.3
0.6	$L_1(S)/L_{00}$	0.621	0.582	−6.3	0.607	−2.3
0.8	$L_1(S)/L_{00}$	0.564	0.541	−4.1	0.551	−2.3
1.0	$L_1(S)/L_{00}$	0.517	0.508	−1.7	0.510	−1.4
1.2	$L_1(S)/L_{00}$	0.476	0.482	+1.3	0.470	−1.3
1.4	$L_1(S)/L_{00}$	0.442	0.459	+3.9	0.438	−0.9
1.6	$L_1(S)/L_{00}$	0.413	0.437	+5.8	0.414	+0.2
1.8	$L_1(S)/L_{00}$	0.388	0.416	+7.2	0.391	+0.8
2.0	$L_1(S)/L_{00}$	0.368	0.397	+7.9	0.368	+0.0
	L_2/L_{00}	1.451	1.395	−3.9	1.455	+0.3
	L_3/L_{00}	0.350	0.368	+5.2	0.352	+0.6

Conclusions

Calculations representative of a broad range of room characteristics suggest that rooms with extreme differences in proportion but with equal domance display transfer ratios which generally are not different by more than ten per cent. Luminous emittance ratios computed by a three-surface representation of symmetrical rooms may be employed to predict accurately the detailed illumination distributions within rooms. An iterative process is available to reduce the truncation error to very low levels. A method for the transformation of three-dimensional to two-dimensional problems is suggested as a technique to reduce the labor of computing detailed illumination and luminous emittance distributions.

References

1. Caraccioli, F. B.: "Calcolo dell' illuminazione artificiale degli ambienti chiusi," *L'Ingegnere* (Italy), No. 10 (1952).
2. Spencer, D. E.: "Approximations and the Interflection Method," ILLUMINATING ENGINEERING, Vol. LIII, No. 5, p. 243 (May 1958).
3. O'Brien, P. F.: "An Analogue Computer for the Predetermination of Luminance Patterns," Preprint P-59.18, XIV Sessions of the Commission Internationale de L'Eclairage, Brussels (June 1959).
4. O'Brien, P. F. and Howard, J. A.: "Predetermination of Luminances by Finite Difference Equations," ILLUMINATING ENGINEERING, Vol. LIV, No. 4, p. 209 (April 1959).
5. Dourgnon, J.: "La Theorie des Reflexions Mutuelles Applique on Calcul du Facteur d'Utilisation," *Cahiers du Centre Scientifique et Technique du Batiment* (September 1955).
6. Boast, W. B.: *Illumination Engineering*. McGraw-Hill Book Co., Inc., pp. 197-221 (1953).
7. Hamilton, D. C. and Morgan, W. R.: "Radiant-Interchange Configuration Factors," National Advisory Committee for Aeronautics, Technical Note 2836 (December 1952).
8. Centeno, M. and Zagustin, A.: "Interflectance in Two Dimensions," Universidad Centrol de Venezuela, Caracas (1953).

DISCUSSION

W. E. MURRAY:* Mr. O'Brien's paper is a fine, concise, and scholarly piece of work. The title evokes a desire to examine the contents. The scope of such a study of 35,000 rooms, with useful results constrained to ten pages, including tabulation, is in itself a task of no small magnitude. This has, however, been accomplished and represents a significant contribution to our store of useful and reliable design parameters.

I wish to raise two questions. The first pertains to mathematic equalities; the second is one of practical application.

Equation (5) on the third page uses the symbol L_n on each side of the equality, with apparently different meanings. Persons familiar with the development will of course recognize the ratios as partial derivatives with respect to the three independent variables L_{o1}, L_{o2}, L_{o3}. Equation (5) may be the integral of a total differential equation $L_n = \int d\,L_n = \frac{L_n}{L_{o1}} \cdot L_{o1} + \frac{L_n}{L_{o2}} \cdot L_{o2} + \frac{L_n}{L_{o3}} \cdot L_{o3}$, due to linearity of the partial differentials; or, equation (5) could be shown as the summation of components $L_n = \sum_{m=1,2,3} L_{nm} \cdot L_{om}$. Then $L_n = \frac{L_{n1}}{L_{o1}} \cdot L_{o1} + \frac{L_{n2}}{L_{o2}} \cdot L_{o2} + \frac{L_{n3}}{L_{o3}} \cdot L_{o3}$. Perhaps the use of transfer ratios with double subscripts, L_{nm}/L_{om}, would be a more general and preferred form.

The symbols were grouped in such a way that their integrity was retained by the IBM 709 digital computer, as L1L01, L1L02, etc., and the results are not in question.

The practical application of the tables is quite interesting. The comment that the variation of emittance values from a square room to an infinite hallway is less than eight per cent for light rooms, and less than 12 per cent for dark rooms, indicates an average deviation of five per cent based on a room of intermediate shade. The values are well within the standard tolerance of ten per cent for engineering approximation. To accept this known error does not, however, seem necessary.

To use the tables for illumination or luminance distribution with disregard for the five per cent deviation would sacrifice some of the potential benefit of Mr. O'Brien's work. His study evaluates the geometric extremes of room shape, and the tabulated transfer ratios must also encompass all intermediate room shapes, including odd-shaped finite rooms, which we most often encounter. A method of interpolation is possible, and I would like to know if one has been developed that will retain the high accuracy of this scientific approach.

I would suggest a fractional interpolation method based upon some parameter which is easily obtained, yet descriptive of the degree of lack of squareness, if you like. For example, the differential-finite shape moduli, such as F_{x-1}, not associated with the end wall, vary continuously from square rooms to infinite hallways. These moduli can be obtained for a series of whole number ratios of length L to width W, for a standard eight-foot room height. These yield a short list of L/W *vs* fractional interpolation factors for use with Mr. O'Brien's values for square rooms and infinite hallways having the same domance as the actual room. This method would provide an approximation much within the five per cent deviation. The tables provide a means for obtaining very accurate results, limited only by the designer's estimate of reflectances. Here is the point upon which the most accurate method always meets difficulty.

The method of transformation from three-dimensional finite rooms to two-dimensional infinite hallways of twice the height is evidently a method to facilitate measurement of shape moduli for calculation of detailed distribution, not an interpolation method for finite room average emittances. Will Mr. O'Brien please confirm this?

Of particular value for industrial application is the method outlined for obtaining detailed luminous flux distribution. The ability to proceed directly to a point solution, from Table II through Table X and five shape moduli, qualifies this as a powerful practical aid to the designer. He can see from equation (6) the predominant surface reflectances, and perhaps select surface materials accordingly.

The usual room is of course complicated by furnishings and equipment, such as switchboards and panels, that represent interference or partial room dividers. An adequate method is needed to allow for these, as well as for windows. Subdivision of rooms and adjustment of average reflectances, or an iterative method such as Mr. O'Brien uses in Table XIII, are possible approaches to provide for these practical room situations.

The theory of matrices has found great application in the analysis of electromagnetic fields. It is quite natural that it be applied to the visual spectrum, despite certain anomalies which are not present in single-frequency radiation problems. When coupled with a powerful analytic tool such as the IBM 709 digital computer, simultaneous solutions become quite practical. Needless to say, few of us are so favored.

It is to the benefit and advancement of the Society that Mr. O'Brien has such an advanced and versatile mathematic tool at his command, and is able to apply it to practical illuminating problems, displaying the results in a directly usable manner. I fully expect the data in his paper to form a basis for closer prediction of luminance and intensity. Surely, among the 35,000 rooms analyzed, and with interpolation to multiply this number, one will always match the odd-shaped room with which we are directly concerned.

R. O. PHILLIPS:* It is now clearly established that the effects of interreflections can be predicted with very satisfactory accuracy by the finite-difference method, even when only three room surfaces are considered.[1] Professor O'Brien is to be congratulated on taking the logical next step and applying the method to a large range of conditions, thus providing the lighting designer with the most comprehensive set of interreflection data yet available. It is to be hoped that the present abstract will be amplified by publication of the complete tables.

An interesting feature of the tables is the comparison between values for square and infinitely long rooms. Although it has been known that the effect of room shape can be represented with close approximation by the single parameter k_r, the degree of error introduced seems to have received little attention. This paper gives data for the two extremes, so that the maximum extent of the possible error can be seen. However, the question then arises as to which of these two shapes gives the best approximation for the true value in a rectangular room of given proportions. Some data on this question are presented below.

In a room of length a and width b, and any given k_r, the value of the ceiling-to-floor shape modulus F depends principally on k_r, but also to some extent on the ratio a/b. Examination of Tables II to X shows that the effect of this difference is relatively greatest with high values of k_r and with

*Dept. of Water and Power, City of Los Angeles, Calif.

*University of New South Wales, New South Wales, Australia.

TABLE A—Comparison of Luminous Emittance Ratios for Rooms of Various Length/Width Ratios.

($k_r = 1.0$; $\rho_1 = 0.3$; $\rho_2 = 0.5$; $\rho_3 = 0.1$)

Length / Width	Emittance Ratios	Per cent diff.	Emittance Ratios	Per cent diff.	Emittance Ratios	Per cent diff.
	L'_1/L_{o1}		L_1/L_{o2}		L_1/L_{o3}	
1	0.2656	.....	0.0776	.....	0.0837	.....
2	0.2662	+0.23	0.0773	−0.38	0.0834	−0.36
3	0.2670	+0.53	0.0767	−1.16	0.0831	−0.72
4	0.2676	+0.75	0.0764	−1.54	0.0828	−1.08
5	0.2680	+0.90	0.0761	−1.93	0.0826	−1.32
7	0.2686	+1.13	0.0758	−2.32	0.0824	−1.56
9	0.2690	+1.28	0.0755	−2.70	0.0822	−1.80
∞	0.2703	+1.77	0.0747	−3.73	0.0816	−2.51
	L_2/L_{o1}		L'_2/L_{o2}		L_2/L_{o3}	
1	0.5175	.....	0.0337	.....	0.1343	.....
2	0.5148	−0.52	0.0335	−0.60	0.1366	+1.71
3	0.5115	−1.16	0.0332	−1.49	0.1393	+3.72
4	0.5091	−1.62	0.0330	−2.08	0.1413	+5.21
5	0.5072	−1.99	0.0329	−2.38	0.1428	+6.33
7	0.5050	−2.41	0.0327	−2.97	0.1447	+7.74
9	0.5035	−2.70	0.0325	−3.56	0.1459	+8.64
∞	0.4980	−3.77	0.0321	−4.75	0.1504	+11.99
	L_3/L_{o1}		L_3/L_{o2}		L'_3/L_{o3}	
1	0.1116	.....	0.0269	.....	0.00938	.....
2	0.1112	−0.36	0.0273	+1.49	0.00943	+0.53
3	0.1108	−0.72	0.0279	+3.72	0.00949	+1.17
4	0.1104	−1.08	0.0283	+5.21	0.00954	+1.71
5	0.1101	−1.34	0.0286	+6.32	0.00958	+2.13
7	0.1098	−1.61	0.0289	+7.44	0.00963	+2.67
9	0.1096	−1.79	0.0292	+8.55	0.00966	+2.99
∞	0.1088	−2.51	0.0301	+11.90	0.00978	+4.26

low reflectance. A comparison has therefore been made with the data of Table XII ($k_r = 1$, $\rho_1 = 0.3$, $\rho_2 = 0.5$, $\rho_3 = 0.1$), since these represent conditions where any differences would be relatively great. Data are presented in Table A for the ratio a/b equal to 1, 2, 3, 4, 5, 7, 9, and ∞ (the first and last of course being the same as in the original table). Luminous emittances due solely to interreflections have been considered to avoid the masking of differences on the input surface by the influence of the direct flux. This applies to the three ratios L'_1/L_{o1}, L'_2/L_{o2} and L'_3/L_{o3}, the notation L'_1 indicating $L_1 - L_{o1}$. The difference column indicates the percentage difference between the value for the given ratio of a/b and the value for $a/b = 1$ (square room).

Inspection of this table shows that in every case the value for $a/b = 5$ lies about halfway between those for the square and the infinite rooms. Since this fact depends mainly on the values of the shape modulus, it is interesting to see how this varies for values of k_r other than 1.0. Some comparisons may be seen in Table B, for a/b equal to 1, 5 and ∞. The difference columns are percentage variations from values for the square room. Again it can be seen that values for $a/b = 5$ lie approximately midway between those for the square and infinite rooms, except for $k_r = 0.5$ where the differences are, in any case, negligible.

TABLE B—Values of the Ceiling-to-Floor Shape Modulus for Rooms of Different Proportions.

	ρ				
k_r	$a/b = 1$	$a/b = 5$	Per cent difference	$a/b = \infty$	Per cent difference
0.1	0.8270	0.8237	−0.40	0.8198	−0.87
0.3	0.5795	0.5733	−1.07	0.5662	−2.30
0.5	0.4152	0.4154	+0.05	0.4142	−0.23
0.7	0.3044	0.3135	+3.0	0.3205	+5.3
1.0	0.1998	0.2190	+9.6	0.2361	+18.2
1.5	0.1107	0.1351	+22.0	0.1623	+46.6

It therefore seems safe to conclude that for all rooms whose length is up to five times their width, the values for the square room should be taken; for longer rooms, values for the infinite room are more accurate. If this procedure is adopted, the error caused by room shape will rarely exceed five per cent, and in most cases will be very much less.

1. O'Brien, P. F., and Howard, J. A., "Predetermination of Luminances by Finite Difference Equations," including discussion. ILLUMINATING ENGINEERING, Vol. LIV, No. 4, pp. 209-218 (April 1959).

JEAN DOURGNON:* No doubt this very extensive paper will prove valuable and useful. Two items seem quite new to me—(a) the use of $\rho/(1-\rho)$, which is the "equivalent reflectance" of a hollow sphere, and (b) the use of an equivalent room of infinite length instead of an equivalent square room, which simplifies the calculation of transfer functions.

I wonder if a difference as great as 20 per cent (Table XI, last figure of the second column) is not caused for the most part by the procedure. This is an arbitrary procedure necessary to reconcile Moon and Spencer's data (involving ceiling, total walls from ceiling to floor, floor, and working plane at three-quarters of the distance from the ceiling to the floor) in another form involving ceiling, part of the walls between working plane and ceiling, and working plane. Direct comparisons made by Didier Fluery and myself (Communication du Centre Scientifique et Technique du Batiment au Comité d'experts de la CIE, nº 3 .1.1.1 Septembre 1957) showed differences less than 10 per cent in similar cases.

P. F. O'BRIEN:** The author wishes to thank the discussers for their helpful and stimulating comments.

Mr. Murray's comment relative to the symbol for luminous emittance on the left side of equation (5) is certainly well-taken. The original manuscript had a bar over this symbol and this has been re-established in the published version of the paper which accompanies this discussion.

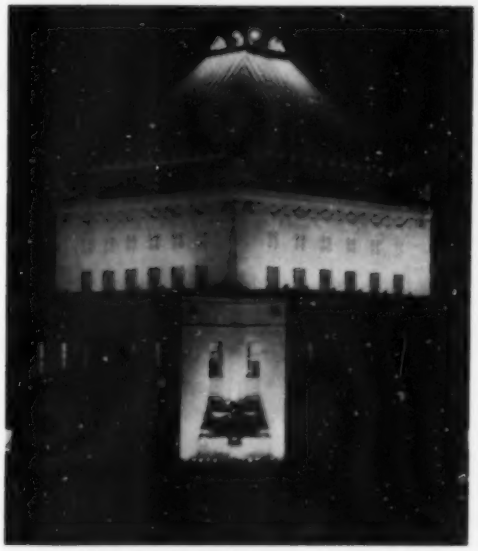
In reply to Mr. Murray's question regarding interpolation and extrapolation, it seems that the luminous quantities describing rooms not given in the table can best be obtained through the use of the transfer functions given in Table I. Some graphical representation of these functions would certainly be helpful for interpolation and extrapolation. Such a set of graphs has been prepared by the author. This question is best answered, however, in the discussion presented by Mr. Phillips.

The author confirms Mr. Murray's interpretation of the objective for transforming finite rooms to two-dimensional infinite hallways for analysis.

Mr. Phillips is certainly correct in considering only the component of the transfer ratio concerned with multiple reflections. His conclusion regarding the use of a length-to-width ratio of 5 as representative of a room intermediate in proportion between the two extremes is elegantly derived and is certainly a very important contribution. In addition, his observation about the quantities characteristic of the rooms of extreme proportion and at a domance of 0.5 is borne out by the data contained in the extensive tables of the paper.

In reply to Mr. Dourgnon, no transformation of Moon and Spencer's data was required for the comparison given in Table XI. The comparisons given here involve the average luminous emittances of the various room surfaces rather than the average illumination on the work plane. This may account for the larger difference reported here.

*Centre Scientifique et Technique du Batiment, Paris, France.
**Author.



INSTALLATION AT THE CINCINNATI GAS AND ELECTRIC CO.,
CINCINNATI, OHIO

Floodlighting a Building's Tower

LIGHTING OBJECTIVE: To illuminate an office building's tower to produce a striking and distinctive nighttime appearance.

GENERAL INFORMATION: This building is located in the basin area of the city. As a result only the upper portion of the building is visible from a distance. In addition, a six-floor annex limits visibility on two sides from the street below. Floodlighting, therefore, was limited to the vertical surfaces on the top three floors and to the decorative copper roof, as shown above.

INSTALLATION: Two Westinghouse CAK-14 floodlighting units, each equipped with one 400-watt H1LS clear mercury lamp, are mounted on each of the four sides of the cupola to illuminate the patina of the copper roof. Clear mercury lamps are used to bring out the blue of the patina.

Forty-eight Westinghouse CAK-14 units, each equipped with 500-watt PS-40 incandescent lamps and clear lenses, are mounted on the terraces formed by the setback construction at the 15th floor. These units provide a uniform maintained level of 40 footcandles, vertical, around the four sides of the 15th floor, giving form to the building structure.

Twelve Westinghouse CAK-14 units, each equipped with one 500-watt PS-40 incandescent lamp and an amber color lens, are mounted at each of the four corner decorative recesses at the 13th floor-level. Four similar floodlighting units are mounted in each of the urns located in these recesses. The recesses are illuminated with amber light to complement the blue color of the roof.

It was possible to accomplish the aiming of the floodlighting units in one night by observing the results from surrounding buildings some distance away and relaying aiming instructions by walkie-talkies.

Lighting designed by George H. Seiter, Cincinnati Gas and Electric Co., Cincinnati, O.

Lighting data submitted by H. K. Flint, Westinghouse Electric Corp., Cincinnati, O., as an illustration of good lighting practice and to aid in the design of similar installations.

Published by the Committee on Publications of the Illuminating Engineering Society, 1860 Broadway, New York 23, N. Y.

Series XXIV
4-60

A.I.A. File No. 31*f*

On the Foundations of Goniophotometry

By DOMINA EBERLE SPENCER
S. M. GRAY

A method is described for extending the concepts of reflectance and transmittance to surfaces that cover the entire range from perfectly specular to perfectly diffusing. Whereas present goniophotometric measurements depend on both the characteristics of the sample and the characteristics of the goniophotometer, the proposed system is believed to measure reflecting and transmitting characteristics of the sample, irrespective of details of construction of the goniophotometer.

IF ILLUMINATING engineering is to advance, one of the requirements will be more definite information on the light reflected or transmitted by imperfectly diffusing surfaces. Data are needed on pavement reflectances, reflectances of schoolroom materials, reflectances of industrial tasks, and reflectances and transmittances of materials used in luminaire design.

The present goniophotometric procedures are unsatisfactory both from a logical and from an empirical point of view. Since practical surfaces cover the entire gamut from the perfectly specular to the perfectly diffuse, one would logically expect that the system of specification would have to be sufficiently general to cover all cases. However, even the most recent goniophotometric studies[1] are based on a concept which is strictly applicable only in the special case of perfectly diffusing surfaces (where goniophotometry itself is not required). The concepts of transmittance and reflectance can be extended to cover the separation of specular and diffuse components which are functions of angles. The paper presents a logical theoretical foundation which is applicable to all types of surfaces.

Empirically, it should be possible to make measurements on a sample which will permit the prediction of its appearance when illuminated by any arrangement of light sources. The prevailing custom is to run off numerous goniophotometric curves of the light reflected from a sample as a function of angle, without a rigorous analysis of exactly what photometric concept is being measured. Unfortunately, the quantity that is measured depends on both the characteristics of the sample being tested and on the illuminating and viewing system of the goniophotometer. While these measurements provide a qualitative description of the "gloss" of a reflecting sample or of the "hiding power" of a transmitting sample, they do not give enough information to predict the appearance of the surface under other illuminating and viewing arrangements.

The paper describes simple procedures by which goniophotometric measurements may be made which are independent of the exact viewing and illuminating conditions and are characteristics of the sample alone. A method is given for resolving the transmitted or reflected light into diffuse and specular components. Measurements are given for a few samples.

A paper presented at the National Technical Conference of the Illuminating Engineering Society, September 7-11, 1959, San Francisco, Calif. AUTHORS: University of Connecticut, Storrs, Conn., and Sylvania Lighting Products, Salem, Mass., respectively. Accepted by the Papers Committee as a Transaction of the IES.

Transmittance

Fig. 1 shows a sample of a transmitting surface, such as a sheet of clear glass or diffusing plastic. The direction of the sample is specified by the unit normal vector N. The observer or the photoelectric receiver is located at point R and looks toward the

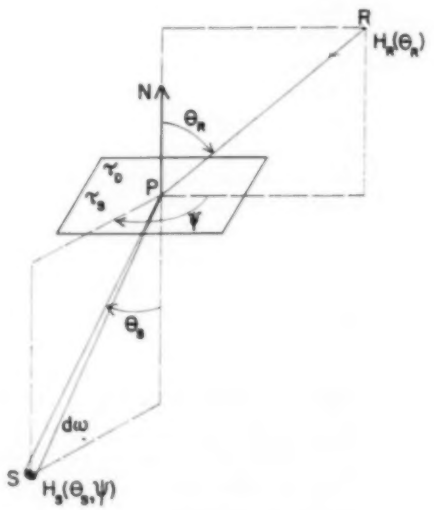


Figure 1.

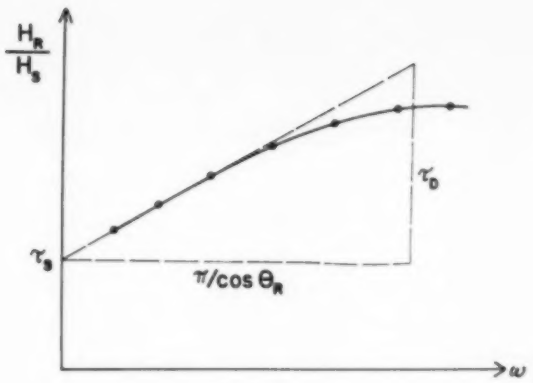


Figure 2.

point P of the sample at an angle θ_R with the normal. A source of light is placed behind the sample at S. The angle of incidence of the light on the sample is θ_S. The angle ψ is the angle measured in the plane of the sample between the two planes perpendicular to the sample which contain the receiver and the source of light. At the point P, the source subtends a small angle $d\omega$.

The appearance[2] of the sample as viewed at R depends on the number of lumens per unit area per unit solid angle received in the direction PR through a small solid angle whose light cone converges at P. Thus, the appearance of the sample as viewed in direction θ_R is specified by measuring the helios (brightness,* if defined in terms of a convergent light cone at the receiver), $H_R(\theta_R)$ at point R in the direction RP. This quantity may be measured by placing a Luckiesh-Taylor or a Macbeth meter at the point R and employing visual measurements or photoelectrically by an instrument such as the Spectra Spot Meter.

In the general case, the appearance of the sample is affected by both the geometry of the light sources and by $H_S\ (\theta_S, \psi)$ as measured at point P in the direction PS. However, if the transmittance is entirely specular, and if the sample is viewed in a transparent medium, then the appearance is independent of the size of the light source as long as S, P and R lie on a straight line (or $\theta_R = \theta_S$ and $\psi = \pi$). Then for purely specular transmittance τ_S

$$H_R\ (\theta_R) = \tau_S\ (\theta_R)\ H_S\ (\theta_R, \pi). \qquad (1)$$

*The present IES nomenclature gives two distinct definitions of brightness: one in terms of a light cone which diverges from the source, the other in terms of a light cone which converges at the receiver. These two distinct definitions are specifically equated in the Third Edition of the *IES Lighting Handbook* despite the physical fact that they may differ by a factor of 10, 100 or 10^6 in such important illuminating engineering applications as street lighting. Only the concept measured in terms of the light cone which converges at the receiver is of visual significance.

On the other hand, if the sample is perfectly diffusing, its appearance is quite independent of how bright the light sources are or their exact arrangement. All that matters in this case is the number of lumens per unit area that are incident on the sample. Thus, for purely diffuse transmittance τ_D

$$H_R = \tau_D\ \frac{1}{\pi} \int \cos\theta_S\ H_S\ (\theta_S, \psi)\ d\omega. \qquad (2)$$

Here the appearance will be the same for all angles of view so H_R is independent of angle. The integral is evaluated over a hemisphere centered at P (for θ_S summed from 0 to $\pi/2$ and ψ from 0 to 2π).

The general case must include the extreme cases described by Eqs. (1) and (2), and be applicable to the surface which is neither perfectly diffusing nor perfectly specular. A formulation which appears to be of sufficient generality to cover all cases is

$$H_R\ (\theta_R) = e^{-\alpha l_{PR}} \left[\frac{1}{\pi} \int \tau_D\ (\theta_R; \theta_S, \psi) \cos\theta_S \right.$$

$$\left. H_S\ (\theta_S, \psi)\ d\omega + \tau_S\ (\theta_R)\ H_S\ (\theta_R, \pi) \right]. \qquad (3)$$

Here, it is assumed that the sample may be viewed in an attenuating medium[3] with attenuation coefficient α at distance l_{PR} from the sample. In general the diffuse transmittance τ_D is a function of the three angles θ_R, θ_S, and ψ. The specular transmittance τ_S is a function of only one angle θ_R. For a perfectly specular surface $\tau_D = 0$. For a perfectly diffusing surface $\tau_S = 0$ and $\tau_D =$ constant.

To discover a method of resolving the diffuse and specular components of transmittance, consider a single source of light which subtends the small solid angle ω at P and appears uniform as viewed from P. Then, from Eq. (3)

$$\frac{H_R\ (\theta_R)}{H_S\ (\theta_R, \pi)} = \frac{\cos\theta_R}{\pi}\ \tau_D(\theta_R; \theta_R, \pi)\ \omega + \tau_S\ (\theta_R). \qquad (4)$$

Now measure (H_R/H_S) as a function of ω for a succession of small solid angles. In the limit as ω becomes very small the curve approaches a straight line as shown in Fig. 2. The intercept of the straight line with the vertical axis is τ_S. The slope of the straight line is $(\cos\theta_R/\pi)\ \tau_D$.

In order to resolve the specular and diffuse components at the specular angle three conditions must be satisfied:

(1) The source of light must appear uniform as viewed by sample and receiver.

(2) The diameter of the uniform source of light must be variable.

(3) For most accurate determination of the specular transmittance as well as simplest form of equations, the source must be large enough to fill the entire field of view of the receiver.

The procedure may perhaps be more easily visualized if outlined in terms of photocell readings and distances to be measured in an actual laboratory situation. For simplicity, consider the case of normal incidence, Fig. 3. A source S of radius r_s which appears uniform as viewed from P and R illuminates the sample. A photocell placed at R reads D_s lumens per unit area when the source is viewed directly and D_R lumens per unit area when the sample is in place. The distance from source to sample is l_s. Then elementary photometrics shows that Eq. (4) here reduces to

$$\frac{D}{D_s} = \left(\frac{r_s^2}{l_s^2 + r_s^2} \right) \tau_D\,(0+0, \pi) + \tau_S\,(0). \quad (5)$$

Thus a plot of the ratio of the two photocell readings for several values of source radius r_s gives the desired information on specular and diffuse transmittance at normal incidence. The result is independent of aperture radius r_A and of its distance l_A from the photocell provided the field of view of the photocell is entirely filled by the source. The aperture r_A must be reduced sufficiently so that this condition is satisfied if Eq. (5) is to be equivalent to Eq. (4). Extension of the procedure to other angles of incidence is obvious.

When we deal with non-specular angles, the procedure is much simpler. If $\theta_R \neq \theta_s$, or $\psi \neq \pi$ then there is no specular component. For laboratory measurements, Eq. (3) becomes

$$\frac{H_R\,(\theta_R)}{H_S\,(\theta_s, \psi)} = \frac{1}{\pi}\,\tau_D\,(\theta_R; \theta_s, \psi)\,\cos\theta_s\,\omega$$

or

$$\tau_D\,(\theta_R; \theta_s, \psi) = \left(\frac{\pi}{\omega \cos\theta_s} \right) \frac{H_R\,(\theta_R)}{H_S\,(\theta_s, \psi)}. \quad (6)$$

The only requirements on the laboratory arrangement are:

(1) The source must appear uniform as viewed from the sample and receiver.

(2) The field of view of the receiver must be reduced sufficiently to exclude all of the source.

As θ_R approaches θ_s and ψ approaches π, the radius of the aperture of the photocell will have to be reduced or the radius of the source will have to be cut down enough so that this condition is satisfied.

Reflectance

Exactly similar procedures may be used to measure specular and diffuse reflectances. In place of Fig. 1 we have Fig. 4 and in place of Eq. (3)

$$H_R\,(\theta_R) = e^{-\alpha l_{PR}} \left[\frac{1}{\pi} \int \rho_D\,(\theta_R; \theta_s, \psi)\,\cos\theta_s \right.$$

$$\left. H_S\,(\theta_s, \psi)\,d\omega + \rho_S\,(\theta_R)\,H_S\,(\theta_R, \pi) \right]. \quad (7)$$

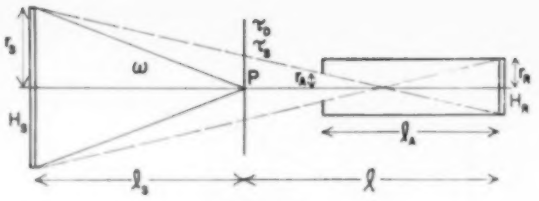


Figure 3.

The experimental procedures are exactly as in the case of transmitting surfaces and need not be repeated here.

Example

In the photometric laboratories at Sylvania, an extensive program of goniophotometric measurements of transmittance and reflectance is anticipated. By placing suitable apertures in front of a large uniform source, we find that the necessary variation of solid angle can be introduced. The goniophotometer[4] was loaned to Sylvania for use in this research. Future papers are expected to give extensive data on many types of samples.

Here, a single example is sufficient to illustrate the novel features of the new method of resolving specular and diffuse components. As in Eqs. (4) and (5) there is a linear relation between the diffuse and specular components of transmittance at a given angle of incidence. For simplicity abbreviate in the form

$$y = \tau_D\,x + \tau_S. \quad (8)$$

Here x is varied when the solid angle subtended by the source is changed, while y is the resulting relative photocell reading. Fig. 5 and Table I show the results obtained at normal incidence with three samples of glass:

Sample 1 (one side acid frosted),
Sample 2 (one side sand blasted),
Sample 3 (two sides sand blasted).

The curves of y versus x are not linear but may be

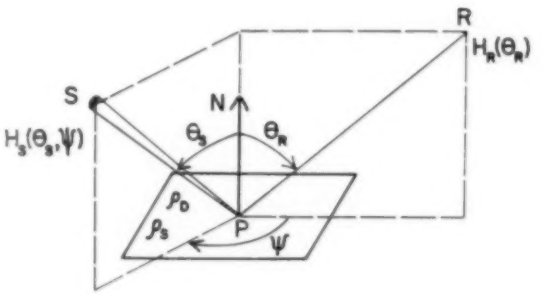


Figure 4.

TABLE I.

x	y		
	Sample 1	Sample 2	Sample 3
0.0180	0.639	0.176	0.0574
0.0132	0.523	0.139	0.0456
0.0111	0.454	0.120	0.0400
0.0099	0.405	0.110	0.0385
0.0083	0.352	0.091	0.0287
0.0075	0.314	.....	.....
τ_S	0.062	0.011	0
τ_D	34.2	10.30	3.70

approximated by straight lines in the limit as x approaches zero. As plotted in Fig. 5, the slope of this straight line is the diffuse transmittance τ_D. The intercept obtained by extrapolating the data to zero solid angle (or to $x = 0$) is the specular transmittance. For these three samples, all of which look like good diffusing glasses, the specular component is small in magnitude compared to the diffuse component, as shown in Table I. In fact, for Sample 3 the specular component is zero (to the accuracy of the photometric measurements). However, this does not mean that the contribution of the specular component to the appearance when one looks through at normal incidence is negligible. For, as is evident from Eq. (3) or (4), the coefficient multiplying τ_S is hundreds or thousands times greater than that of τ_D for small sources. Thus, neglect of the specular component is not justified.

At first glance, it may be surprising to see diffuse transmittances greater than 1. A little thought will show, however, that there is no reason why diffuse transmittance should not exceed unity for some angles, provided that it drops below unity at others. The only limitation is that the number of lumens transmitted through a sample cannot exceed the number incident on it. But the light transmitted can be distributed in an arbitrary angular pattern with high peaks near the specular angle.

Measurements such as shown in Fig. 5 for a variety of source sizes should be made at each specular angle. From these, values of specular and diffuse reflectance at specular angles are readily calculated. At non-specular angles only a single measurement is needed. Here the new restriction is that care must be taken to eliminate completely any specular component by sufficiently restricting the aperture of the receiver.

Conclusions

The paper has presented a method of measuring both diffuse and specular reflectances and transmittances of any sample. The novel feature is that a series of measurements is made for various sizes of source at each specular angle. These permit the calculation of both diffuse and specular quantities. A uniform source of variable diameter is required. Care must be exercised in design of equipment so that (1) the source fills the entire field of view of the receiver at specular angles or (2) the source is excluded from the field of view of the receiver at non-specular angles.

The next step in this research should be the measurement of diffuse and specular components for a wide range of materials of importance in illuminating engineering. If diffuse and specular reflectances were available for luminous ceiling diffusors, an exact treatment could be given of permissible lamp arrangements for uniformity. The nebulous concept of hiding power could be put on a rational basis. Measurement of specular and diffuse reflectances of reflecting materials used in controlled fluorescent equipment would permit an exact pre-

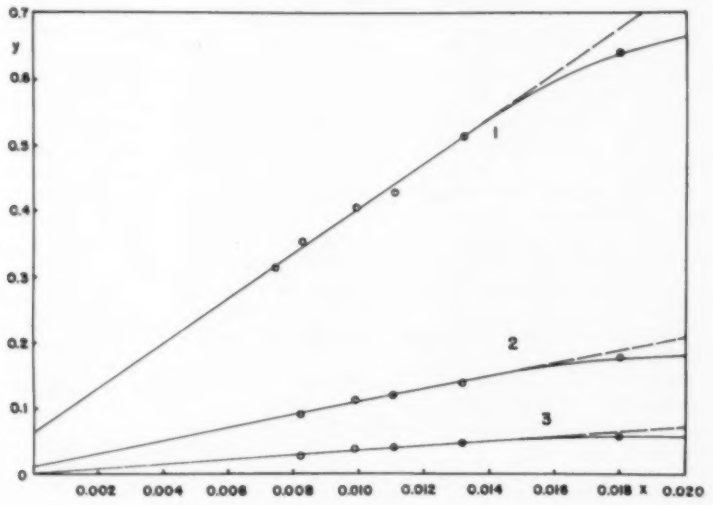


Figure 5.

diction of the light spilled above the theoretical cut-off plane and a more exact treatment of the distribution of light close to the luminaire. The problem of reflected glare from books, desks, writing paper and drafting materials awaits an exact treatment until specular and diffuse reflectances of such materials can be measured. Then it will be possible to predict the effect of any combination of luminaires, from downlights to luminous ceilings. Design of optimum luminaires for runways and turnpikes requires a knowledge of the specular and diffuse reflectances of pavement materials. Low-mounted fluorescent is utilized so close to grazing angles that design based on diffuse reflectance is meaningless.

Other extensions that should be made include the study of polarization and color. Complete information requires two sets of measurement with polarization parallel and perpendicular to the sample. Specular and diffuse components may also differ in color, the specular component depending more on the color of the source, the diffuse component being largely determined by the color of the sample.

References

1. Finch, D. M.: "Visibility Measurements on Several Schoolroom Visual Tasks Under Different Lighting Conditions," Illuminating Engineering Research Institute Vision Research Symposium, Dearborn, Mich., March 3-4, 1958.

Kraehenbuehl, John O.: "Measurement of Pavement Surface Characteristics," ILLUMINATING ENGINEERING, Vol. XLVIII, No. 5 (May 1952).

Nimeroff, I.: "Analysis of Goniophotometric Reflection Curves," *J. Res. National Bureau of Standards*, Vol. 48, page 441 (1952).

Nimeroff, I., Hammond, H. K. III, Richmond, J. C., and Crandall, J. R.: "Specular-Gloss Measurement of Ceramic Materials," *J. Am. Ceramic Society*, Vol. 39, page 103 (1956).

Nimeroff, I.: "Two-Parameter Gloss Methods." *J. Res. National Bureau of Standards*, Vol. 58, page 127 (1957).

2. Moon, Parry, and Spencer, D. E.: "Photometry," Encyclopedia Brittanica, Vol. 17, pages 480-485, 1948 Edition.

3. Spencer, D. E.: "A Scattering Function for Fogs," to be published.

4. Moon, Parry, and Laurence, J.: "Construction and Test of a Goniophotometer," *J. Opt. Soc. Am.*, Vol. 31, page 130 (1941).

Laurence, J.: "Reflection Characteristics with Polarized Light." *J. Opt. Soc. Am.*, Vol. 31, page 9 (1941).

DISCUSSION

I. NIMEROFF AND C. A. DOUGLAS:* This paper presents an ingenious method which, in theory at least (if the assumptions are correct), will separate the specular and the diffuse components of reflectance and transmittance. The usefulness of this method will be determined by the following factors:

(a) The utility of the concept of measurements separating the specular and diffuse components of reflectance and of transmittance as compared to the utility of goniophotometric measurements of the total reflectance or transmittance as customarily made with instruments in which the angular sizes of the source and receiver are very small or where the measurements are extrapolated to zero angular size of source and receiver;

(b) The accuracy with which the specular and diffuse components can be measured;

(c) The convenience with which these components can be measured.

*National Bureau of Standards, Washington, D. C.

Goniophotometric data as now obtained (measurement of flux as a function of angle) give an indication of the spatial distribution of light transmitted or reflected by a specimen. From time to time different techniques have been suggested and used to make estimates of how this distribution is composed of specular and diffuse components. Only in two classes of materials is it possible to make a reasonably good estimate of these components. These are: (a) specimens in which the diffuse component is a very small part of the flux, and (b) specimens in which the specular component is a very small part of the flux. Some of the methods of estimating the components for reflecting materials have been described by Laurence[1] and Tanaka[2] using polarization techniques, and by Hammond and Nimeroff[3] using expansion of the perfect diffuse concept. These techniques are, admittedly, only estimates.

Difficulty in all specular-diffuse separation procedures comes from the meaning of diffusion. Harrison[4] states that, "Diffuse reflexion is simply a concise way of saying that the surface is optically so irregular that reflected and refracted rays leave the surface in all directions. The surface need not appear rough to the eye, and the changes of direction which bring about the diffusion need not all take place at the surface, but may be due to repeated reflexions and refractions within the material." Thus, it is almost impossible to say whether a ray found at a direction other than the specular angle to the gross plane is specularly reflected or diffusely reflected.

Further difficulty arises from the fact that for most specimens the specular direction is not clearly defined. Only in the ideal case is there a unique specular angle, but for most practical surfaces and media there is no such angle. One may speak of the specular direction for a polished surface and for the gross plane of any surface, but for all other surfaces this direction is not unique. Each facet or elementary area has its own specular direction. Harrison shows also that from a shallow water wave, described by the function $y = 0.2679 \sin x$, the specular (Fresnel) reflection of light incident at 45 degrees from the earth's surface (gross plane) gives two maxima, one at 15 degrees and one at 75 degrees from the perpendicular to the gross plane, but not at 45 degrees as might be expected at first thought.

In practice, the light incident on the receiver at R comes not from the point P but only from a small area surrounding P. Within this small area are elemental increments of area at varying small angles from the gross plane of the specimen even though the surface may appear to be specular. For each of these elemental areas there is a unique specular angle, hence there is no one angle for which specularly transmitted or reflected light from all points within the small area surrounding P will be incident on a receiver at R unless the source at S is larger than a certain minimum size. Therefore when ω is smaller than this minimum size, τ_s (as measured) will not be independent of the size of the source. Also when the size of the source is larger than a given size, for a given angle of illumination θ_s, there will be a range of angles, $\theta_R \pm \triangle\theta_R$ for which there is some specular, in addition to the diffuse, reflection or transmission.

Spencer and Gray make an erroneous assumption concerning the uniqueness of the specular angle. For instance Middleton and Mungall[5] in their study of reflection of snow find "that the angle of maximum reflectance is greater than the angle of incidence." To account for this Middleton and Mungall introduce two corrections to their theory. First a statistical counting is made of the surface facets whose normals lie within a given angular range so that reflected rays may lie within a given solid angle. Second, an estimate

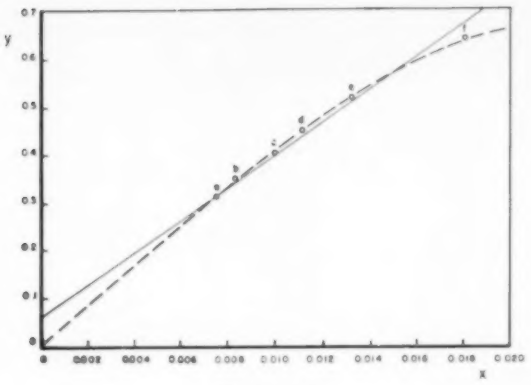


Figure A.

is made of the correction factor required for the masking of incident as well as reflected flux by jutting facets. No such approximate corrections are made in the Spencer-Gray paper.

This method, regrettably, is not very precise. The procedure necessitates the mechanical measurement of a large number of small solid angles, the photoelectric measurement of very low levels of flux, and the linear extrapolation far beyond the measurements. Each of these contributes to the ultimate uncertainty of the results. The authors have assumed that on curve 1 of Fig. 5 all points except the uppermost one lie on the straight portion of the curve and they have extrapolated over a range of x's greater than the range covered by the five remaining points to obtain τ_S. On Fig. A of this discussion we have added a broken line curve to curve 1 of Fig. 5 of the paper. Our curve, which assumes that the straight portion starts at about point 1, appears to fit the data as well as, if not better than, the authors' curves; yet it yields a quite different value for τ_S. (In Fig. A point d, which was apparently misplotted in Fig. 5 of the paper, has been plotted at the location given by the data of Table I.) To further test the precision an analysis of the data listed by the authors in Table I was made. We computed for Sample 1 least square lines of the form, $y = mx + b$ where m is the slope and b the intercept of the line, based on the 5, 4, 3, and 2 points nearest the origin. The results of the analysis, including the mean, Mn, and the standard deviation, σ, are shown in Table A. It is apparent that measurements must be made with sources of angular subtense smaller than those used by the authors before an extrapolation for τ_S can be made with accuracy.

Some measure of the precision and value of the proposed method can be obtained by a comparison of measurements made at different locations on the sample. Another measure of precision would be the making of a series of measurements with varying angular subtense of the source when the angle of viewing was near but not equal to the angle of illumination to see if the intercept of the line is zero and the slope is equal to the slope at the specular angle. Have such measurements been made? Has a study been made to verify experimentally the assumption that the values of transmittance obtained are independent of the size of receiver and of receiver aperture even though the source is large enough to fill the field of view of the receiver?

TABLE A.

Number of Points Used	Slope, m	Intercept, b
5	36.4	+0.046
4	38.0	+0.032
3	34.2	+0.066
2	47.5	−0.042
Mn	39.0	+0.025
σ	4.9	0.040

The convenience of the method is subject to serious question. As the materials of practical interest are not perfectly diffusing or specular, nor are they a simple combination of the two, measurements must be made for a large number of combinations of angles of incidence and of viewing. As stated in the paper, a single measurement at each point is sufficient if there is no specular transmission or reflection. However, since there is often specular-type transmission or reflection for conditions other than $\theta_R = \theta_R$ and $\psi = \pi$ and since τ_R and τ_D cannot be assumed to be independent of the angle of incidence, many series of measurements with a source of varying angular size may be required for each angle of incidence. Sources of smaller angular size than the minimum used here are required. Hence, the receiver size must also be reduced. Thus, instrumentation of very high sensitivity will be required, perhaps of higher sensitivity than economically permissible.

1. Laurence, J.: "Reflection Characteristics with Polarized Light," *J. Opt. Soc. Am.*, Vol. 31, page 9 (1941).
2. Tanaka, S.: "Measurement of Reflection Characteristics of Paper Using Polarized Light," *J. Appl. Phys., Japan*, No. 25, p. 207 (May 1956).
3. Hammond and Nimeroff: *J. Res. National Bureau of Standards*, Vol. 44, p. 585 (1950).
4. Harrison: "Definition and Measurements of Gloss" *PATRA* (1945).
5. Middleton and Mungall: *J. Opt. Soc. Am.*, Vol. 42, p. 572 (1952).

D. M. FINCH:* I wish to review this paper for several reasons: there seem to be some inconsistencies in terminology, several concepts are not clear, and there are disparaging references to past and present work on directional reflectances which are unwarranted.

The authors state that "The present goniophotometric procedures are unsatisfactory. . . ." May I ask, from whose point of view are they unsatisfactory? It appears that the authors wish to reserve "goniophotometry" as their own special device for measuring a type of reflectance or transmittance. Actually, many very satisfactory goniophotometers are in use for measuring many different attributes of materials or devices wherein a spatial distribution of intensity or brightness as a function of angular direction is required. I would suggest a change in the title so that it more clearly indicates the substance of the paper.

In the opening paragraphs reference is made to recent studies (by me) which are "strictly applicable only in the special case of perfectly diffusing surfaces." Either the authors are not entirely familiar with the techniques employed in these recent studies or they do not understand the problem. Since neither seems to be the case, some discussion is in order.

The paper is concerned with the directional transmittance or reflectance of materials and most of the emphasis is placed upon an assumed specular direction. It should be noted that a specular direction can only be defined for perfectly smooth mirror type surfaces and that even in such cases the measurements are to be certain extent influenced by the measuring technique. This is true for the method described in this paper as for all other past and present schemes.

*Professor Electrical Engineering, University of California, Berkeley, Calif.

I note that τ_s and τ_D are used to denote "purely specular" and "purely diffuse" transmission in eqs. (1) and (2). These concepts are described in conventional terms in the adjacent paragraphs. In subsequent equations and discussion τ_D is shown as a function of three angles, τ_D (θ_R, θ_S, ψ).

Thus the transmittance is shown as not "perfectly diffuse" in the general case. Why then refer to this term as "diffuse transmittance?" A better name would be *directional transmittance*.

Equation 3 indicates that the brightness of a surface under a given set of conditions (θ_R, θ_S, ϕ) can be considered to consist of two parts, one due to scattered light from the material and one due to non-scattered light from the source. The term dealing with scattered light is shown to be the *illumination* at the surface times a factor. For all angles except $\theta_S = \theta_R$ and $\psi = \pi$ this is the only term since $\tau_S = 0$. Thus the actual brightness is shown to be the Illumination $\times$ Brightness Factor. This is precisely the principle that has been presented in the work that the authors object to.

To use the idea of directional transmittance or reflectance it is necessary to be able to specify the direction angles. Therefore, the size of the source should be small and the solid angle of the receiver should be small. With an instrument meeting these requirements one can get all of the required information by scanning the brightness pattern at a known illumination.

The special case of a mirror or non-scattering surface requires special treatment. The authors have shown one special procedure which is unnecessarily complicated. For a truly non-scattering medium one merely has to measure the illumination produced at the receiver by a small source seen directly and by the source seen through the medium. The ratio is the desired quantity, τ_S or ρ_S.

The concept of Brightness Factor $= \dfrac{\text{Brightness}}{\text{Illumination}}$ can be applied to all types of design problems involving actual surfaces including those that are almost but not quite "purely specular." The special case of mirror or non-scattering media must be handled separately. This is true even in this paper.

I raise the question: How is one to use τ_S and τ_D for calculation purposes if these quantities should become available?

D. E. Spencer and S. M. Gray:* We particularly appreciate the thoughtful and suggestive comments of Messrs. Nimeroff and Douglas. The sense in which we have generalized the concepts of specular and diffuse reflectance should first be clarified. We have assumed the reflected light contains a component that is proportional to the number of lumens-per-unit area incident on the surface. The coefficient of proportionality has been called *diffuse reflectance* ρ_D (θ_R; θ_S, ψ) since, in the special case in which ρ_D is independent of angle, ρ_D becomes the familiar reflectance of a perfectly diffusing surface. The other component of the reflected light depends only on how bright the source is and is entirely independent of how large the source may be. This is the familiar meaning of the specular reflectance of a perfectly specular surface. The definitions of Eqs. (3) and (7) have the advantage of reducing to the proper expressions at the extremes of perfect specularity and perfect diffusion.

It should be noted that we have assumed nothing at all about the shape of the diffuse reflectance function ρ_D (θ_R; θ_S, ψ). It may have peaks at any angle whatsoever. We have, however, assumed that the surface of the sample is sufficiently well-defined so that any specular reflection occurs with $\theta_R = \theta_S$ and $\psi = \pi$. As Messrs. Nimeroff and Douglas point out, there is the possibility that the surface may have a regular structure which will produce true specular reflections at other angles. To cover this contingency, the fundamental Eqs. (3) and (7) may be generalized to the form

$$H_R(\theta_R) = e^{-\alpha l_{PR}}\left[\frac{1}{\pi}\int \tau_D(\theta_R;\theta_S,\psi)\cos\theta_S\, H_S(\theta_S,\psi)\,d\omega + \int \tau_S(\theta_R;\theta_S,\psi)\,d\,H_S(\theta_S,\psi)\right] \quad (3a)$$

and

$$H_R(\theta_R) = e^{-\alpha l_{PR}}\left[\frac{1}{\pi}\int \rho_D(\theta_R;\theta_S,\psi)\cos\theta_S\, H_S(\theta_S,\psi)\,d\omega + \int \rho_S(\theta_R;\theta_S,\psi)\,d\,H_S(\theta_S,\psi)\right]. \quad (7a)$$

In the generalzed form, we retain the fundamental characteristic that the diffuse component is proportional to $H_S d\omega$ while the specular component is proportional to H_S alone. Throughout, it is assumed that the size of the sample measured is large compared to surface irregularities.

Reference to the Middleton and Mungal paper, for example, does not indicate whether this generalization is required. Their maxima for snow are not exactly at the specular angle. However, as the authors do not distinguish between diffuse and specular components, it is impossible to tell whether these maxima are of a diffuse or specular nature. This is an interesting topic for further research.

The ultimate limit in the precision with which ρ_D and ρ_S can be determined is not ascertained in our paper. The data given are meant to be illustrative rather than definitive. The number of experimental points required is not necessarily large, but should certainly be arranged in such a way that the straight line is determined as accurately as possible. This, too, is a topic for further study.

Experimental work is also needed to demonstrate that the specular and diffuse quantities are truly independent of details of construction of the goniophotometer and that verifiable results are obtained by superposition as indicated in Eqs. (3) and (7). We hope to undertake such work in the near future.

The discussion of Professor Finch is rather confused. He seems to have missed entirely the fundamental idea of the paper. The concept of brightness factor cannot be correctly applied in any practical cases except those in which the specular component is entirely absent.

For the use of τ_S and τ_D, should they become available, he can be referred to Eq. (3) and, if he does not understand the concepts involved, to an introductory text on lighting calculations (for example, Chapters I, III and IV of *Lighting Design* by Moon and Spencer).

Professor Finch suggests that we may not be familiar with the techniques employed in his recent goniophotometric studies. It is an interesting coincidence that the research assistant responsible for a major part of the laboratory work in Professor Finch's paper is now working on goniophotometry at Sylvania. Through him, we feel that we are very familiar with Finch's techniques. It is also interesting to note that Finch's former assistant is now convinced of the deficiencies of the concept of brightness factor.

*Authors.

Questions & Answers on Light Sources

The IES Light Sources Committee under the chairmanships of E. H. Salter and H. A. Anderson has prepared these answers to questions concerning light sources. Readers are invited to submit similar questions of general interest to be considered for publication. Questions should be sent to the Light Sources Committee, care of IES Headquarters.

Question: An electrical contractor in Victoria, B. C., reported that he and several other contractors have been experiencing unexplained loading effects on fluorescent circuits. For example, he states that a fluorescent circuit fused at 15 amperes with 1000 watts or less connected load, when energized, will often rupture a 15-ampere fuse and, furthermore, the rigid conduit used for the circuit actually gets hot. The Provincial electric wiring code limits the ampere load on such circuits to 12 amperes but frequently this is found to be inadequate. The city wiring inspector reported frequent installations of this nature which have developed these characteristics. It would appear that this effect could be caused by the use of low power factor ballasts resulting in heavy inductive current in the circuit, resulting in fuse rupturing. However, this does not explain the heating effect in the conduit with standard No. 14 B&S gauge copper wire, the minimum called for by the code.

Answer: The first and most likely cause of fuse failure in a situation of this kind is the possibility of low power factor ballasts. There is also the possibility that the original current calculations were based on lamp watts and assumed 100 per cent power factor. Since all high power factor ballasts operate somewhere between 90 per cent leading and 90 per cent lagging, this could lead to an error in current calculations of as much as 15 to 20 per cent.

Another possibility is that there is some initial surge above normal operating current. Power factor corrected ballasts with a capacitor across the primary or an extended part of the primary winding can attain momentary high currents due to capacitor charging. Such high currents added to the line from several ballasts could blow quick-acting fuses. With most ballasts the duration of this surge is about one cycle. If very fast acting fuses are involved or if longer surges occur, this may contribute to the fuse failure.

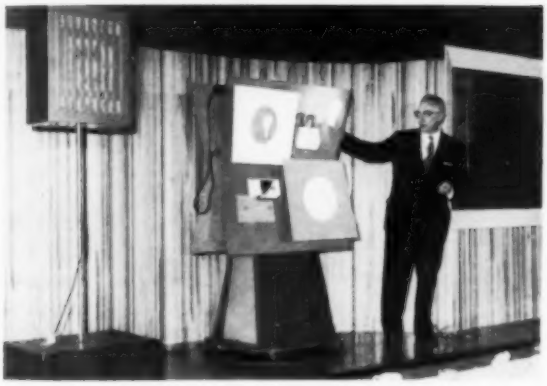
If three-phase circuits are involved there is a possibility of third harmonic neutral currents building up to nearly equal line current. This would contribute to conduit heating, particularly if neutral wire were not as large as the others, but should not affect line fuses. This third harmonic would contribute to copper loss as well as the minor inductive heating of the conduit itself.

A final possibility is that some lamps rectify, that is, pass current every other half cycle during the starting phase. With older lamps, the duration of this rectifying condition may be so long that the increased line current which usually results may cause the fuse failure.

Question: A number of hospital operating rooms have been equipped with fluorescent lighting that is either too "warm" or too "cold." In consequence, it may be difficult to judge the patient's color and condition. Could you tell me or refer me to sources that list the color temperature of various fluorescent lamps as well as filament lamps and tell me which of the former are recommended for correct color balance in operating rooms and other hospital areas?

Answer: So far, incandescent luminaires with specially-designed optical control features have been found most satisfactory for operating rooms. They give the best color rendition to skin and wound tissue. If fluorescent lamps are used for general lighting, the recommended color is cool white deluxe. Where possible, all lighting in adjacent rooms should use the same color in order to have the doctors and other personnel adapted to it.

Here and There with IES Members



IES Sections and Chapters and other lighting industry groups in 12 cities played host, during January and February, to a traveling show of light sources which included some 400 sources introduced in the past ten years. Alston Rodgers of the General Electric Lighting Institute in Nela Park and Chairman of IES Lighting Education Committee, was the traveling showman. At table with Mr. Rodgers (standing) as he addressed Utah Chapter on Feb. 9 in Salt Lake City are, left to right in photo at left: William A. Huckins Jr.; Homer Shaw, Section Chairman, and D. R. Dyrenforth. At right, Mr. Rodgers explains quartz-lamp demonstration at Southern California Section meeting.

Recipient of 1959 Citation of Chicago Lighting Institute, awarded for the purpose of giving public recognition to outstanding achievement in the advancement of the science and art of illumination in the Chicago area, was J. Chalmers O'Brien. The Citation was presented to Mr. O'Brien for energetic leadership in the fostering, design and installation of the new Chicago State Street lighting, "the most spectacular street lighting system in the world." Shown with Mr. O'Brien (right) is Arthur E. Swedenborg, director of the Institute and vice-president, Benjamin Division of Thomas Industries, Inc., Des Plaines, Ill.

IES First Vice-President R. G. Slauer spoke about the research activities of the Society at the Tar Heel Section meeting at Duke University on Feb. 23. The meeting, held in co-ordination with Engineering Week, was attended by numerous student guests as well as IES members. Pictured with Mr. Slauer (left) are Cecil L. Cannon, Roy Palmer and Llew Cordle.

Technical publication welcomed as IES Sustaining Member. Arthur L. Rice, Jr., executive vice-president of Technical Publishing Co. (left), presents Sustaining Member check to John J. McLaughlin, Chicago Section, as evidence of support and interest in lighting research and work of IES. Thomas E. Hanson (right), editor of company's publication, *Plant Engineering*, witnesses transaction.

LIGHTING NEWS

Status of Current Researches Presented
Third IERI Symposium, Washington, D. C.

Final conclusions for two more basic lighting research studies, both by Pritchard and Blackwell, were reported at the IERI Symposium, Washington, D. C., March 3 and 4. Reports on six other IERI research projects still underway gave interesting glimpses of further basic lighting knowledge yet to come. The occasion was the two-day meeting sponsored by the Illuminating Engineering Research Institute at the Sheraton Park Hotel, Washington, D. C. Some 97 researchers and serious lighting application engineers battled the winter's worst eastern storm to attend the meeting. A few highlights of the presentation included:

Roadway Lighting—How Much, Under What Conditions? Documentation of this study by Benjamin S. Pritchard and H. Richard Blackwell, Ohio State University, which is now completed, is expected to provide street and roadway lighting engineers with a basis for specifying the required level of illumination for a variety of roadway lighting conditions. In his Symposium presentation, Dr. Blackwell outlined in detail the methods of their study, describing the instrumentation and numerous factors involved. Using the Blackwell Visual Task Evaluator, and an additional instrument developed for this study (Pritchard-Fry meter for measuring disability glare), measurements were made at the Hendersonville Street Lighting Laboratory for nine typical roadway visual tasks, at 200-feet viewing distance, under different lighting conditions, to determine the footcandle level needed for supra-threshold level, after allowance for disability glare. Basis for evaluation was the Dearborn standard brightness curve, 99 per cent accuracy and a field factor of 15. Tables showing the results were presented. Footcandle levels indicated ranged from 0.7 to 2.8,

A. F. Wakefield

C. L. Crouch

G. A. Fry

H. R. Blackwell

W. C. Allphin

Mrs. O. M. Blackwell

R. N. Boynton

R. C. Bradley

Harry Helson

Photo at left: Dr. L. C. Mead, President of Tufts University, speaker at dinner session, March 3. In center, honored at dinner, left to right: A. F. Wakefield, Chairman, IERI Trustees; H. M. Sharp and Ward Harrison, Past-Presidents of IES; L. C. Mead. At podium, C. L. Crouch, Secretary, IERI and Technical Director, IES. Photo at right, John E. Kaufman, Technical Assistant, IES, who tape-recorded the Symposium Proceedings.

depending on the nature of the object to be seen, the traffic lane in which it was measured, and the disability glare present (which varied with different light sources, pavement surfaces, mounting heights, etc.).

Sight Through Fog—Dr. Blackwell described these studies also, speaking for Mr. Pritchard who is currently seriously ill. Following difficulties with an experimental installation built on the New Jersey Turnpike (the difficulties being fog dispersal before the researchers could get there), a scale model of the turnpike was built in which fog of varying densities could be made at will. This enabled studies which involved not only the optical properties of fog (as established by Pritchard and to be published by the *Journal of the Optical Society of America*), and theoretical phases of seeing in fog, but also very practical trial and error methods involving many variations. The scale model also included model cars and carefully constructed handmade model light sources; car headlight and taillight candlepower distribution was successfully simulated. Some conclusions: In fog, street lighting cuts down visibility 20 feet; if taillights are on, best to have no street lighting; the possible answer, beef up the taillights. No taillights in fog, hazard greater. For visibility of car ahead, overhead lighting on car body proved superior to low-mounted lights, better still with high reflectance car body. However, bumpers were seen better with low-mounted lighting. There is some possibility that forward lights at 60 degrees are superior for seeing the car body. If street lights are on in fog, better to turn off the headlights. The studies quantify how much variation to expect in various conditions, in fog, and a table was shown for the visibility distances for auto body under various methods of illumination.

Color Preferences—This is a study, not yet completed, undertaken over the past several years by Dr. Harry Helson, Professor of Psychology, University of Texas. With colored slides to demonstrate his test methods, Dr. Helson reported on several phases of his study, for example, the degree of acceptance of some 125 Munsell colors against 20 different background colors, and as seen under five different light sources, using 10 observers. Observations were also made on foods and on complexions, not only under various light sources but under different lighting levels. Results of the literally hundreds of thousands of answers for the numerous factors involved in the test were put through an IBM machine to obtain preferences. Although final analysis of the data is yet to be made, there are several interesting regularities already observed. Dr. Helson feels that an analysis of these data will give practitioners something valid to go on concerning color preferences, under what light source, and against what background; ditto what least preferred.

Visual Acuity and Visual Aberrations—This was an interesting research presented by Mrs. O. Mortenson Blackwell (wife of Dr. B.), who is also associated with the Institute for Research in Vision at Ohio State. Her studies were started with IERI assistance, but are continuing under the aegis of the medical profession. Although her studies are concerned with visual defects in people of all ages—nonnorms such as victims of nystagmus, photophobia, fixed pupil and other visual afflictions—it is expected that they will aid in later studies of variances among norms, especially, it is hoped, in studies of the deterioration of older eyes. Mrs. Blackwell's presentation indicates progress in detecting factors involved in reduction of visual acuity. She hopes to extend her work soon to less handicapped people.

Variation in Field of Vision under high and low levels of light is a problem being studied by Dr. Robert N. Boynton, Associate Professor of Psychology and Optics, University of Rochester (N. Y.). His work is concerned with different illumination levels in the field as they affect vision as their contrasts change. Describing his test methods using a fixed observer and fixed background, with measurements made on visual performance under changing levels, Dr. Boynton outlined what happens to the visual system as levels are changed. He noted, in this preliminary report, that performance may be better right after an increase to higher levels, and that it gets progressively better. After long exposure to high levels, the eye gets insensitive to still more light and no further increase in performance is noted. If confronted with a sudden decrease in illumination the response is not so great. Dr. Boynton's interesting presentation was a report on what he is doing, with conclusions to come at a later date.

Discomfort Glare in Practice, by Willard Allphin of Sylvania Electric Products, Salem, Mass. This is not an IERI project, but was undertaken on the advice and with the guidance of the Technical Advisory Committee of IERI. Using naïve observers (men doing the work for contributions to their service clubs) tests were made on their reaction to discomfort glare in simulated office and school conditions. Final results of these "in practice" studies will be reported in a paper before the IES National Technical Conference in Pittsburgh next September. Some interesting preliminary conclusions, however, were presented by Mr. Allphin, indicating that people vary tremendously in their response to discomfort glare, and that the BCD concept has significant meaning since it does apply to the kind of people we are designing lighting for.

Field Instruments and their need was discussed by Dr. Blackwell. Until recently, he said, the only Visual Task Evaluator was the one in his laboratory; however, both Pritchard and Dr. Blackwell have been working on a portable VTE, simpler than its prototype and

(*Continued on page* 11A)

Costs a *little* more

...gives MUCH more

To have fixture BALLASTS that wear this Certification emblem may cost a **little** more, than for non-certified ballasts . . . but you get MUCH more.

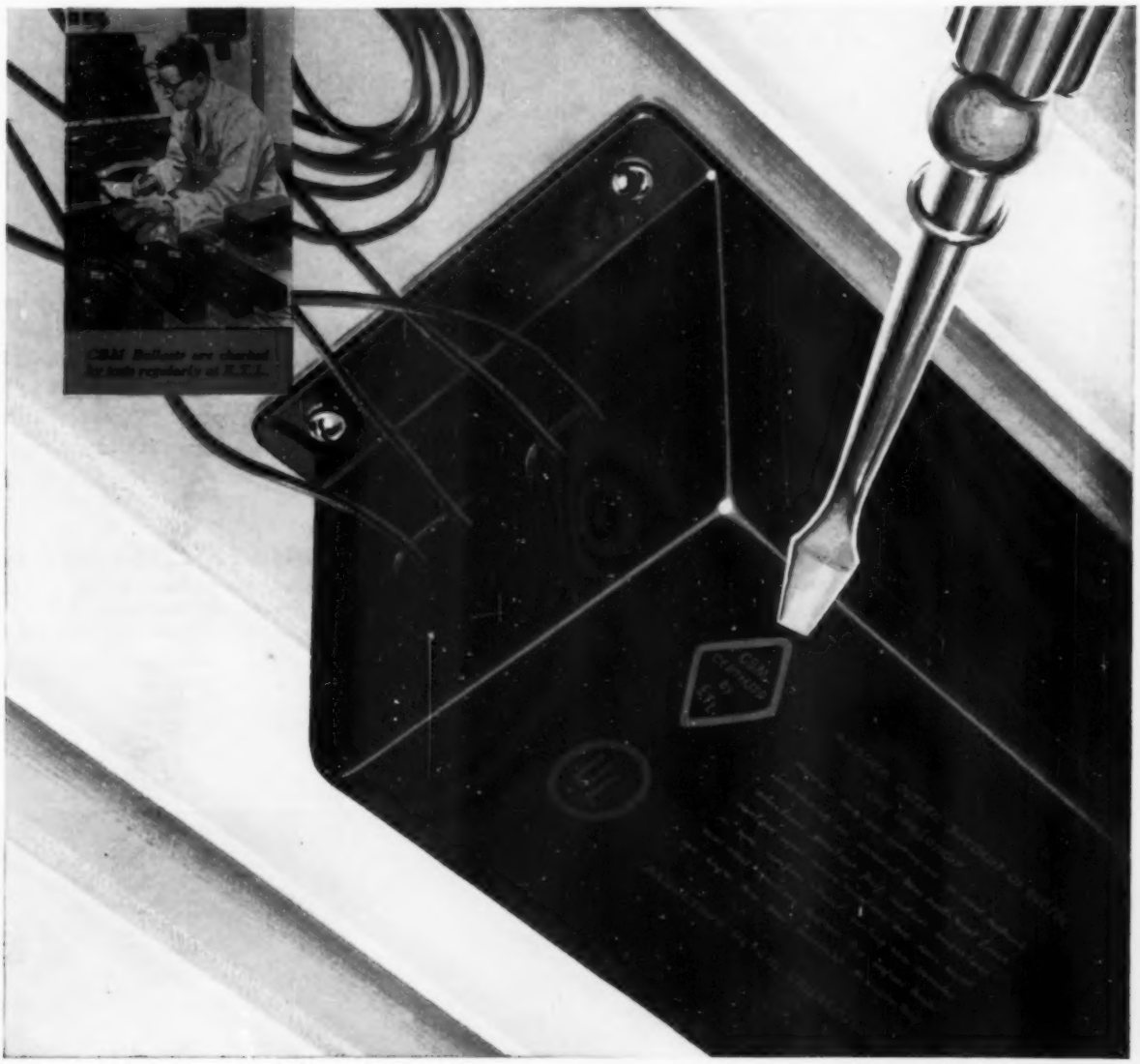
More and better materials in the ballast itself . . . more copper, more steel, and more protective and corrective devices . . . and more inspections, finer workmanship . . . to assure the user "tops" in fluorescent performance. Perhaps this extra value is why an ever increasing number of ballast users find that specified CBM performance . . . checked and certified by ETL . . . is well worth having.

CBM CERTIFIED by ETL ®

Get the full story: Write for a copy of "How to protect your lighting investment", **CERTIFIED BALLAST MANUFACTURERS,** 2112 Keith Building, Cleveland 15, Ohio.

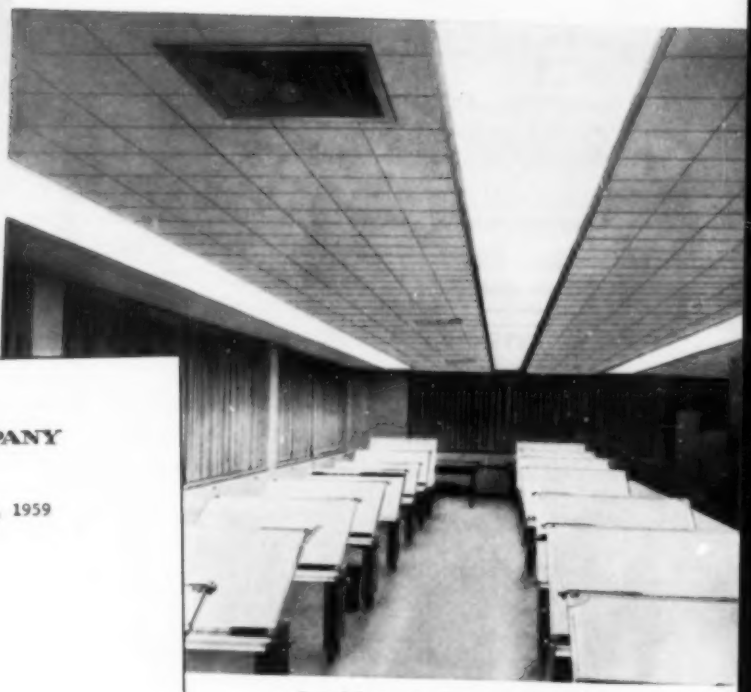
Participation in CBM is open to any manufacturer who wishes to qualify.

3-60



"Holophane is to be congratulated..."

ATLAS POWDER COMPANY expresses high satisfaction with their new lighting system. When Atlas designed the relighting of their Central Engineering Department, Holophane Specification No. 7559-C showed how to provide 170 foot-candles maintained illumination.



Central Engineering Dept., Atlas Powder Company.
Installed by Hatzel and Buehler, Inc.

ATLAS POWDER COMPANY
WILMINGTON 99, DELAWARE

November 13, 1959

Mr. C. C. Keller
Holophane Company, Inc.
342 Madison Avenue
New York 17, New York

Dear Mr. Keller:

We have completed the installation of the Holophane Fluorescent Lighting System, designated as 6404-64, in our Central Engineering Department. The maintained illumination level is 170 foot candles.

The installation has proved very satisfactory from the visual comfort and the illumination level. The graceful styling lends itself beautifully to our surroundings with particular reference to the shallowness of the unit.

Holophane is to be congratulated in designing such a unit from the mechanical and electrical angle. With the ballasts mounted at far sides and opposite corners, it provides cooler and safer operation together with a better weight distribution with respect to installation.

The unit is constructed in such a manner that all parts are readily accessible from an installation and maintenance standpoint. It is our opinion that we cannot offer any constructive criticism or suggestion in order to make this a better unit.

Very truly yours,

ATLAS POWDER COMPANY

CENTRAL ENGINEERING DEPARTMENT
TECHNICAL SERV. SECTION

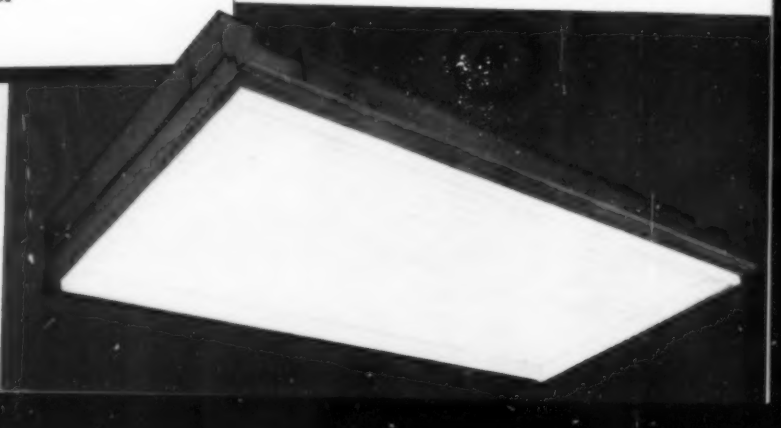
R. G. Rudrow

R. G. RUDROW, MANAGER
ELECTRICAL GROUP

RGR:ms

The entire Holophane organization—particularly the engineers and craftsmen responsible for the development of Holoflux units—is gratified to acknowledge the plaudits from Atlas Powder Company... Recognition of sincere endeavor spurs greater effort and further accomplishment.

HOLOPHANE COMPANY, INC.
Lighting Authorities Since 1898
342 Madison Ave., New York 17, N. Y.
THE HOLOPHANE CO., LTD., 418 KIPLING AVE. SO., TORONTO 18, ONT.



HOLOFLUX®—Recessed 2 Foot Wide Luminaire, featuring PRISMALUME® *(Prismatic Acrylic Plastic)*

No. 6400—Holoflux with prismatic border; in four foot lengths or continuous runs... Distinctive design integrates with contemporary interiors... Prismatic construction provides highest utilization of light, minimum brightness.

WINNERS in the first round of IES's new Applied Lighting Competition, Irene Covington, center (Class I), and H. E. Pritchard, right (Class II), of the Mississippi Chapter are happy recipients of first-prize checks from E. L. Bell, Mississippi Chapter ALC Chairman.

(*Continued from page 8A*)

calibrated in the lab. Several such portable instruments are expected to be available within the next six months, for use by other IERI projects.

Reflected Glare was also discussed by Dr. Blackwell in another presentation, describing work which supplements the Chorlton-Davidson studies (see IE, August, 1959). In addition to the measurements with pencil writing, further studies now include numerous other samples such as a page from IE, ball-point, ink, thermofax, etc. Tables he showed summarizing his data indicated the extent to which specular reflection from all of these various samples could be improved using (a) light control, (b) polarization. In regard to these studies he felt that from this point onward engineering application might take over, to develop lighting systems which give the least specular reflection. He noted that results of this work are due to be published within the near future, for IES members to "take from there."

Glare from Large Area Sources and the IERI project to study this, carried out jointly by Robert C. Bradley, Cornell University and R. G. Hopkinson, of the Building Research Station in England, was described by Mr. Bradley. Their complete paper on this project is scheduled for publication in the next issue of IE. For the Symposium he outlined their test procedures and detailed their techniques for evaluating glare from large area sources. (See May, 1960 IE).

Among the other speakers at this most significant Symposium, not directly describing IERI projects, was Eric Pawley, Research Secretary of the American Institute of Architects and a new member of the Technical Advisory Committee of IERI. C. L. Crouch, IERI Secretary (and Technical Director of IES) also spoke, summarizing much of the work being reported, and describing some of the projects soon to be undertaken.

Speaker at the dinner meeting on March 3 was Dr. Leonard C. Mead, Tufts University, Medford, Mass. Demonstrating with fascinating colored movies made in his laboratory, he described tests underway there on eye movements.

Some interesting statistics on the Institute's work: Thirteen projects are now being conducted. Eleven have recently been completed. A total of 44 have been completed during the Institute's 15 years of operation. A recently-developed report by the Trustees covering the year's work during 1959 by the Illuminating Engineering Research Institute is available upon request from C. L. Crouch, c/o IES Headquarters.

Fall Publication Scheduled For Science Encyclopedia

The McGraw-Hill Book Co. has announced that a 15-volume *Encyclopedia of Science and Technology*, in preparation for the past four years, will be published this fall. The encyclopedia, described by McGraw-Hill as the largest technical publication ever undertaken in the English language, will contain over 7000 articles written by some 2000 scientific experts.

The work of the contributors was coordinated by a large group of consulting editors, each a specialist in one of the 62 fields covered by the encyclopedia, including mathematics, engineering, physical science, agriculture, conservation, earth science and space technology. Editor-in-Chief for the project was William Crouse, working under the general direction of an Editorial Advisory Board composed of leading scientists and engineers.

Management Seminar For Engineers

To meet the need for the development of managerial skills in technical personnel holding administrative positions, The Pennsylvania State University, University Park, Pa., will conduct a seminar in Research and Development Management from July 24 to July 29. The seminar, under the direction of J. William Caldwell, associate professor of industrial engineering, includes in its program lecture and workshop sessions on such topics as the development of administrative skills, the role of management, leadership, motivation, communication, training and rating.

Requests for additional program information and tuition charges should be addressed to the Continuing Education Conference Center, The Pennsylvania State University, University Park, Pa.

Third Division Formed Under NEMA Reorganization Plan

In line with the recent reorganization plan approved by the membership of the National Electrical Manufacturers Association, manufacturers of generation, transmission and distribution equipment have announced the formation of the third new Division within the NEMA framework. The Division is comprised of the Capacitor, Hydraulic Turbine, Lighting Protective Devices, Pole and Transmission Line Construction Materials, Switchgear, Steam and Gas Turbine, Transformer, Specialty Transformer, High Voltage Insulator and Electrical Measuring Equipment Sections.

C. H. Bartlett, a member of the NEMA Board of Governors and of the Planning Committee which developed the recommendations leading to the reorganization of the Association, was elected chairman of the new Division.

Decorators' Lighting Symposium at Chicago Lighting Institute

Recognizing the increasing importance of the role of esthetics in lighting design and the need for greater communication between lighting engineers and interior designers, the Chicago Lighting Institute and the American Institute of Decorators co-sponsored a Decorators' Lighting Symposium on March 22.

Speakers at the meeting, representing the lighting and decorating fields, in-

(*Continued on page 12A*)

SEEN at a recent meeting of the Eastern Pennsylvania Section, left to right, front row: J. Henry Bicher, Secretary-Treasurer; Richard A. Reynolds, Section Chairman; Richard C. Hamsher, Vice-Chairman. Back row: R. J. Mott and R. H. Kerchmar, Board of Managers; P. H. Hildebrand, speaker; C. D. Shirley, Boyd Wagner; P. H. Stanley; R. W. Knight; H. B. Koch, Jr., and Roy McCarter. Mr. Hildebrand reported highlights of the CIE Congress, held in Brussels, Belgium, last June.

(Continued from page 11A)

cluded Aileen M. Page, Residential Lighting Specialist, General Electric Co., discussing "Designing for the Functional and Environmental Effect"; Thomas Smith Kelly, lighting consultant—"This Thing Called Light"; C. Eugene Stephenson, Fellow, AID—"Importance of Light Control to the Interior Designer" and John Anderson, Executive Editor, *Interiors* magazine—"A Plea for More Imagination in Lighting."

Karl Steinhauser, President of the Illinois Chapter of AID, served as moderator of the program, which was held at Chicago Lighting Institute headquarters.

MIT Plans Seminar on High Speed Photography

The scientific and engineering applications of high-speed photographic measurement techniques will be the subject of a one-week seminar at the Massachusetts Institute of Technology, Cambridge, Mass., starting August 15, 1960. The seminar, which will center at the Stroboscopic Light Laboratory at MIT, will have its morning sessions devoted to theory and demonstrations with the afternoons reserved for laboratory practice.

Subjects to be covered include pulsed stroboscopic lighting, optical high-speed cameras, Kerr cells, Faraday shutters and image converters. Specialists in high-speed photography have been invited to discuss their subjects at the seminar and give practical laboratory demonstrations of many types of high-speed protographic equipment.

High-speed motion picture and still cameras give space-time resolution for complicated mechanical motions. In some ways they are, for the mechanical engineer, what the cathode-ray oscillograph is for the electrical engineer.

The MIT seminar is under the direction of Professor Harold E. Edgerton of the Department of Electrical Engineering. Further information can be obtained from Office of the Summer Session, Room 7-103, MIT, Cambridge 39, Mass.

Golden Gate Success Formula—Panel Discussion Programs

Use of a panel of experts to stimulate discussions of controversial lighting subjects has proved highly successful at meetings of the Golden Gate Section. Meeting attendance has improved, interest has been keen, discussion from the floor has increased and members feel they have gained a considerable amount of knowledge from these forums.

At the Section's February meeting, the panel discussion, moderated by Robert A. D. Schwartz, United Lighting & Ceiling Co., Oakland, concerned acoustics as related to integrated luminous ceilings where air distribution is involved. Panel members included Fred U. Weir, Bayha, Weir & Finato, Engineers; Dariel Fitzroy, consultant in architectural acoustics; and N. James Hahn, architectural superintendent, Welton Becket & Associates.

Previous meetings were devoted to discussions on principles and criteria for school lighting as applied to advanced educational institutions, plastics in respect to luminous ceilings and the fire and electrical codes applicable to the use of plastics in luminous ceilings.

Le Chapitre de Quebec Presente Cours d'Eclairage

The Quebec Chapter, one of the two French speaking Chapters of IES (St. Mauriee Valley is the other), recently conducted a French language course in lighting design. This course, the continuation of a program started last year in the fundamentals of illumination, emphasized the practical application of lighting techniques.

Classes met for six weekly two-hour sessions at the Faculte des Science de l'Universite Laval with the following program:

7 mars—La vue et l'éclairage—Dr. Jacques DeSerres, optometriste et Les caractéristiques de la lumière—Gerald Dunnigan, Northern Electric Co.
14 mars—L'éclairage des bureaux — Camille Labrecque, Holophane Co.
21 mars—L'éclairage des écoles—Oscar Dorval, Ingénieur conseil.
28 mars—L'éclairage des magasins — G. A. Watters, Quebec Power Co.
4 avril—L'éclairage des industries — Yvan Montcalm, Powerlite Devices, Inc.
11 avril—Lumière et architecture—E. Henri Talbot, architecte.

Gerald Dunnigan, Quebec Chapter Chairman, directed the course.

Decrease Reported in Engineering Enrollments

For the second successive year, the enrollments in accredited engineering colleges in the United States have decreased. In the fall of 1959, 240,063 students were registered in engineering schools, a decrease of 4 per cent from 1958 and 6.9 per cent from 1957.

These decreases were reported at a time when college enrollments were rising, a total of 10.9 per cent in the 1957-1959 period. In 1959, engineering students accounted for only 7.1 per cent of the total college population, as compared with a high of 8.4 per cent in 1957.

These statistics, released in February by the American Society for Engineering Education, were compiled by the U.S. Office of Education in a survey of 154 engineering schools. The survey is conducted each year under the joint sponsorship of the ASEE and the Office of Education and includes all colleges having one or more engineering curricula accredited by the Engineers Council for Professional Development.

Although undergraduate enrollments have declined, the number of advanced degree students increased in 1959, with 6 per cent more master's candidates and 18.4 per cent more doctoral candidates as

(Continued on page 17A)

Here's the latest idea in continuous lighted ceilings...

It's in the new Union Carbide building on New York's Park Avenue. The light-diffusing panels of BAKELITE Brand rigid vinyl sheets are supported by stainless steel runners that are part of the ventilating and cooling systems and also serve to anchor the movable wall partitions.

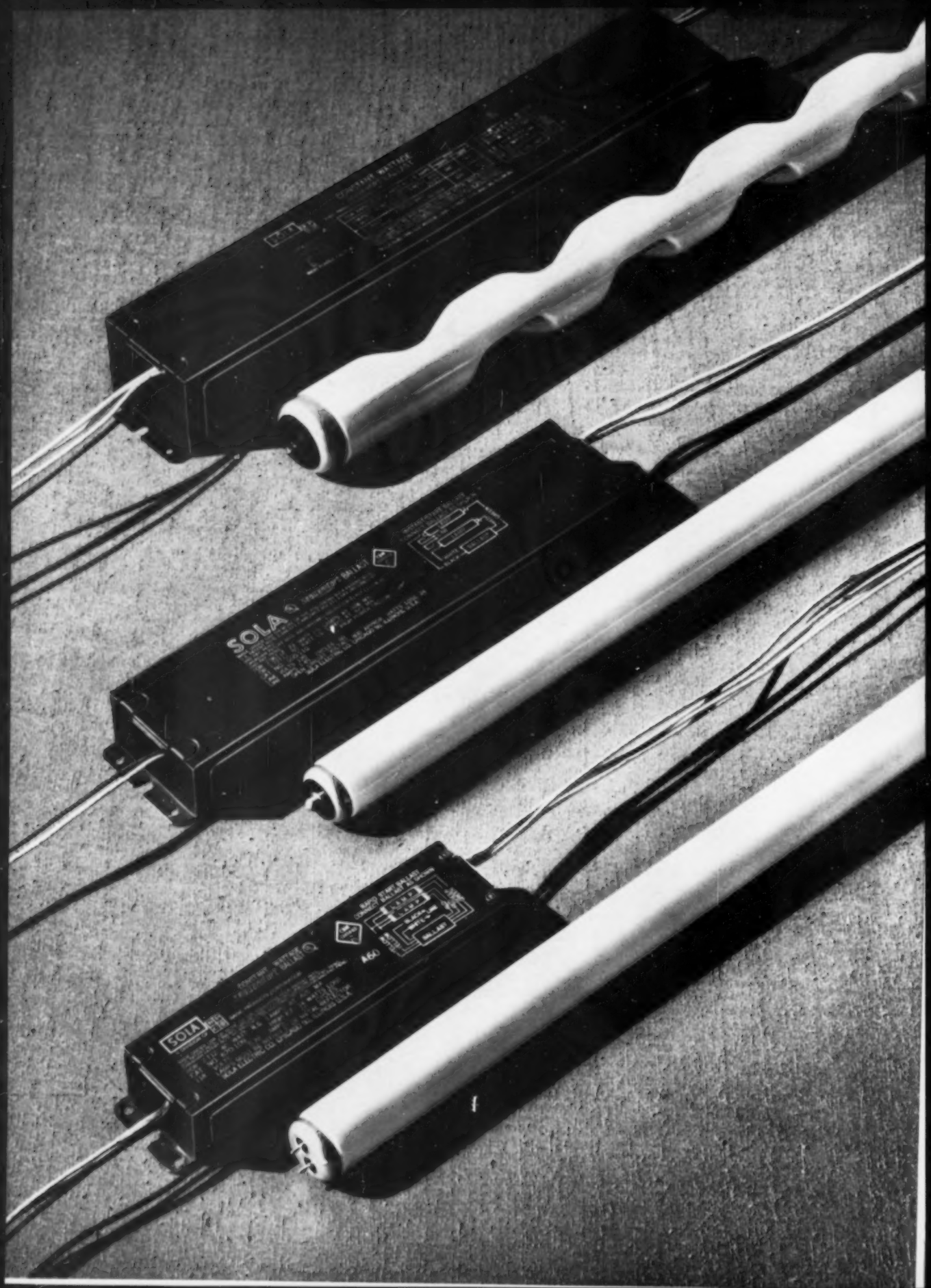
Today, you can get BAKELITE rigid vinyl sheets that are practically immune to the cracking that raises the cost of installing and maintaining continuous lighted ceilings. That's because these sheets are formulated and fabricated especially for light diffusion. They are expected to last for years without yellowing in standard installations.

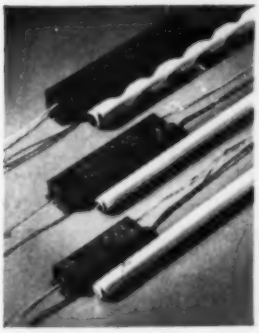
They're self-extinguishing, but the installation can be designed so they'll soften and fall out before the sprinkler operating temperature. Installing them with baffles or laminating with special sound-deadening material gives them good acoustical properties. Costs can be cut because much thinner sheets can be used than for other types of diffusers.

There are many other things to look for in BAKELITE rigid sheets for continuous lighted and luminous ceilings. If you're not getting them all, write for facts, literature and a list of suppliers, Dept. DM-81K. Union Carbide Plastics Company, Division of Union Carbide Corporation, 30 East 42nd Street, New York 17, N. Y. *In Canada:* Union Carbide Canada Ltd., Toronto, Ont.

UNION CARBIDE

"Bakelite" is a registered trade-mark of Union Carbide Corporation.


SOLA



Sola Ballast Catalog Number 670-130
for two 96-inch or 72-inch 1500ma rapid start lamps

Sola Ballast Catalog Number 650-110
for two F96T21 or two F72T12 425ma slimline lamps

Sola Ballast Catalog Number 670-109
for two F40T12 430ma rapid start lamps

Cool thinking results in family of Sola "upside-down" fluorescent ballasts

One of the major problems in modern fluorescent lighting is the problem of ballast heating in an operating fixture. Well ahead of other major ballast manufacturers, Sola engineers started thinking cool and designing cool in terms of in-fixture ballast performance.

Here's the latest of their new ideas in ballasts—the components are mounted *upside down* in the case. The fiber insulator is removed from its conventional position on the mounting surface and put beneath the label surface where it can't trap heat inside the ballast case.

The new design permits normal core and coil heat to be quickly conducted away by the fixture housing and also puts extra space between the capacitor and the core and coil to extend capacitor life. The result is a ballast that works more efficiently, lasts longer, and provides full light output over its rated life—premium performance at no extra cost, proved by repeated in-fixture ballast testing.

Now three Sola ballasts with upside-down insides are available. Manufacturers of quality lighting fixtures, as well as specifiers and users, have been quick to recognize the good sense of the idea—just as they were with other Sola innovations such as the constant-wattage circuit and the series-sequence circuit which are now industry standards.

The cool thinking that resulted in these new ballasts is typical of Sola's comprehensive engineering approach in designing quality products. At Sola, it goes on all the time. Look to Sola when you want ballasts that will help quality fluorescent fixtures deliver all the light that's engineered into their lamps . . . that will give coolest possible in-fixture performance . . . that will live up to their own rated life.

Consult your Sola lighting representative for complete information on Sola products—request literature on "upside down" ballasts.

SOLA

SOLA ELECTRIC CO.

B P C

Write for Bulletin 3D-FL.

Sola Manufactures: Constant Voltage Transformers, Regulated DC Power Supplies, Constant Wattage Mercury Lamp Transformers and Fluorescent Lamp Ballasts

A Division of Basic Products Corporation

4633 West 16th Street, Chicago 50, Illinois, Bishop 2-1414 • In Canada, Sola Electric (Canada) Ltd., 377 Evans Avenue, Toronto 18, Ontario

new 1960 RLM Specifications Book

Brings you New and Upward Revised Standards

BUT

...remember this important fact, this new Edition Announcement emphasizes that RLM Specifications for industrial lighting units are not fixed Standards. They are Quality Standards that advance with the Industry and the Science of Illumination.

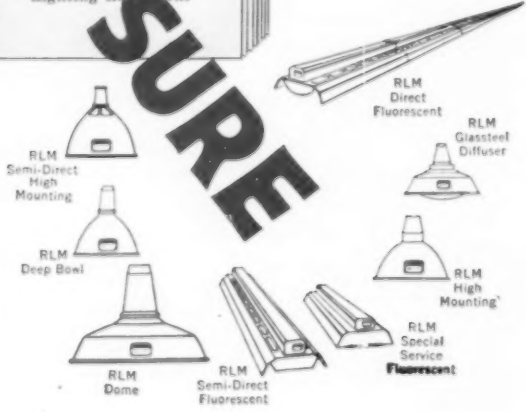
THE FINAL INGREDIENT

PRODUCT QUALITY
LIGHTING QUALITY

OF BEING SURE

RLM Standards are Product Quality and Lighting Quality Standards for Industrial Lighting Equipment. They are moving standards—they move upward with each advance in the art of illumination and with the technological advances for manufacture. That's why we have annual editions of the RLM STANDARDS SPECIFICATIONS BOOK. That's why the 1960 Edition, now off the press, should be in the hands of all who buy or specify lighting—and its quality specifications should be known to all makers and sellers of industrial lighting equipment. For your complimentary copy, mail the coupon today.

These TWIN QQ's to Industrial Lighting Success are guaranteed with all lighting equipment bearing the RLM Label. And again for 1960, there are new and revised STANDARDS! They include: **New Specs for 1500 MA HIGH MOUNTING FLUORESCENT units. Semi-Direct Porcelain Enameled and Aluminum units. • GROUNDING of all component parts. • CONTINUITY OF GROUNDING throughout a continuous row. • SILVER PLATED CONTACTS in all "rapid start" units. • NEW SYNTHETIC ENAMEL Specification for component parts cover (1) rust inhibiting undercoating (2) adhesion (3) hardness.**



RLM STANDARDS INSTITUTE, Inc. Suite 8234, 326 W. Madison, Chicago 6, Ill.

Send free full information including the New 1960 Edition of the RLM SPECIFICATIONS BOOK. (Please write name, company and address in margin below.)

R-764

(Continued from page 12A)

compared to 1958. If the undergraduate figures continue to decline, however, the effect will soon be felt in the graduate schools.

This report on engineering enrollments was compiled by Wayne E. Tolliver of the Higher Education Statistics Unit of the U.S. Office of Education and Dr. Henry H. Armsby, chief for engineering education in the Office of Education's Division of Higher Education. The full report was published in the February 15 issue of the *Journal of Engineering Education*, monthly publication of the American Society for Engineering Education.

Advanced Lighting Techniques Subject of N. Y. Section Course

Following the completion of their fall course in the fundamentals of illumination, the New York Section of IES is offering an opportunity for those schooled in basic lighting techniques to increase their knowledge of illumination. The ten-week course in the design of commercial and industrial lighting installations with emphasis on current lighting trends in these fields began on March 7. Classes meet for weekly two-hour sessions at the offices of The Holophane Co., Inc., in New York City.

Under the direction of Edward L. Gluck, McPhilben Lighting Co., Inc., Brooklyn, N. Y., the curriculum was planned to cover:

March 7—Interior Lighting Design—E. L. Gluck.
March 14—Advanced Lighting Calculations—E. L. Gluck.
March 21—The Blackwell Report in Relation to Office Lighting—R. Wissoker, Day-Brite Lighting, Inc.
March 28—Office Lighting—Part 2—R. Wissoker.
April 4—Industrial Lighting—Part 1—N. Falk, Holophane Co., Inc.
April 13—Industrial Lighting—Part 2—N. Falk.
April 20—Public Building Lighting—L. Goren, Globe Lighting Products.
April 25—Store Lighting—L. Goren.
May 2—Outdoor Lighting—I. Fishman, Port of New York Authority.
May 9—General Review—I. Fishman.

Task Committee Named To Study IES Geography

In response to a growing need for a comprehensive study of the geographic organization of IES, President Joe B. Browder appointed, at the February 12 meeting of Council in New York City, a Territorial and Organizational Task Committee. Scope of the committee is "to study regional boundaries with respect to the preparation of a plan to encompass future growth patterns of the Society."

James R. Chambers, Second Vice-President and Chairman of the Regional Activities Committee was named Chairman

(Continued on page 18A)

SCHEDULED EVENTS

April 20, 1960—Council Executive Committee Meeting, Illuminating Engineering Society, Memphis, Tenn.

April 21-22, 1960— South Central—Southeastern Regional Conference, IES, Hotel Peabody, Memphis, Tenn.

April 25-26, 1960—Southwestern Regional Conference, IES, Robert Driscoll Hotel, Corpus Christi, Texas.

April 27-29, 1960—American Institute of Electrical Engineers, Great Lakes District Meeting, Milwaukee, Wis.

April 28-29, 1960—Inter-Mountain Regional Conference, IES, Mountain Shadows Resort, Scottsdale, Ariz.

May 1-5, 1960 — Electrochemical Society, Spring Meeting, LaSalle Hotel, Chicago, Ill.

May 1-5, 1960—National Association of Electrical Distributors, Dallas, Texas.

May 2-4, 1960—American Institute of Electrical Engineers, Northeastern District Meeting, Providence, R. I.

May 3-5, 1960—South Pacific Coast Regional Conference, IES, Hollywood Roosevelt Hotel, Hollywood, Calif.

May 9-10, 1960—Pacific Northwest Regional Conference, IES, Benjamin Franklin Hotel, Seattle, Wash.

May 10-12, 1960—American Institute of Electrical Engineers (Farm Electrification Conference), Sheraton-Fontenell Hotel, Omaha, Nebr.

May 12-13, 1960—Midwestern Regional Conference, IES, Sheraton Martin Hotel, Sioux City, Ia.

May 12-14, 1960—American Institute of Industrial Engineers, Annual Meeting, Dallas-Sheraton Hotel, Dallas, Texas.

May 16-17, 1960—Great Lakes Regional Conference, IES, Hotel Carter, Cleveland, Ohio.

May 23-26, 1960—National Office Management Association, 41st International Conference and International Office Exposition, Queen Elizabeth Hotel and Show-Mart, Montreal, Que.

May 23-26, 1960—Design Engineering Show, Coliseum, New York, N. Y.

June, 1960—Society of Plastics Engineers, Vinyl Plastics Meeting, Boston, Mass.

June 6-8, 1960—Edison Electric Institute, Annual Convention, Atlantic City, N. J.

June 8-9, 1960—Northeastern Regional Conference, IES, Wentworth-by-the-Sea, Portsmouth, N. H.

June 8-11, 1960—National Society of Professional Engineers, Annual Meeting, Statler Hotel, Boston, Mass.

June 10-26, 1960—British Exhibition (Industry, Technology, Science, Culture), New York City Coliseum, New York, N. Y.

June 12-15, 1960—American Society of Heating, Refrigerating and Air Conditioning Engineers, Annual Meeting, Vancouver, B. C.

June 13-14, 1960—Canadian Regional Conference, IES, Nova Scotian Hotel, Halifax, N. S.

June 16, 1960—Council Meeting, Illuminating Engineering Society, New York, N. Y. Members are free to attend meetings of Council as guests.

June 19-24, 1960—American Institute of Electrical Engineers, Summer General Meeting, Atlantic City, N. J.

June 20-24, 1960—American Society for Engineering Education, Annual Meeting, Purdue University, Lafayette, Ind.

June 27-29, 1960—Canadian Electrical Association, Annual Convention, Manoir Richelieu, Murray Bay, Quebec, P. Q.

August 8-12, 1960—American Institute of Electrical Engineers, Pacific General Meeting, El Cortez Hotel, San Diego, Calif.

August 22-24, 1960—National Association of Lighting Maintenance Contractors, Annual Convention, Milwaukee Inn, Milwaukee, Wis. All meetings are open to public.

September 6-16, 1960—Production Engineering Show, Navy Pier, Chicago, Ill.

September 10-18, 1960—Electrical Living Show, New York Coliseum, New York, N. Y.

September 11-16, 1960—Illuminating Engineering Society, National Technical Conference, Penn-Sheraton Hotel, Pittsburgh, Pa.

September 21-23, 1960—American Society of Mechanical Engineers—American Institute of Electrical Engineers, Power Conference, Bellevue-Stratford, Philadelphia, Pa.

September 28-30, 1960—Canadian Electrical Manufacturers Association, Sheraton-Brock Hotel, Niagara Falls, Ont.

October, 1960—American Society for Engineering Education, Annual Meeting of North-Midwest Section, Marquette University, Milwaukee, Wis.

October 5-7, 1960—International Association of Electrical Leagues, Annual Meeting, President Hotel, Kansas City, Mo.

October 9-14, 1960—American Institute of Electrical Engineers, Fall General Meeting, Chicago, Ill.

October 13-15, 1960—Optical Society of America Meeting, Somerset Hotel, Boston, Mass.

October 15-20, 1960—American Institute of Electrical Engineers, Fall General Meeting, Detroit, Mich.

October 16-22, 1960—Society of Motion Picture and Television Engineers, Semi-Annual Convention, Sheraton Park Hotel, Washington, D. C.

October 19, 1960—Society of Plastics Engineers, Tooling for the Plastics Industry, New York, N. Y.

October 23-27, 1960—National Electrical Contractors Association, Las Vegas, Nevada.

October 25-27, 1960—American Standards Association, National Conference on Standards, Sheraton-Atlantic Hotel, New York, N. Y.

November 14-18, 1960—National Electrical Manufacturers Association (Annual Meeting), Traymore Hotel, Atlantic City, N. J.

November 27-December 2, 1960—American Society of Mechanical Engineers, Annual Meeting, Statler-Hilton Hotel, New York, N. Y.

November 29, 1960—American Institute of Consulting Engineers, Annual Dinner, Waldorf-Astoria Hotel, New York, N. Y.

January 24-27, 1961—Society of Plastics Engineers, Inc., 17th Annual Technical Conference, Shoreham and Park Sheraton Hotels, Washington, D. C.

MEMBERS of the Electrical Club of Montreal who were hosts to IES President Joe Browder at a joint meeting of the Club and the Montreal Section of IES, left to right, front row: Joe Page, Southern Canada Power Co.; G. H. Gaherty, Montreal Engineering; Mr. Browder; John Shepherd, Montreal Section Chairman; Leo Roy, Quebec Hydro-Electric Commission. Back row: Joe Thomas, Director of IES; Fred Patterson, Secretary-Manager, Electrical Club; Bill Massie, Munderloh & Co.; R. N. Coke, Quebec Hydro-Electric; Eric Bushel, Steel Co. of Canada; Len Van Duzer, Peerless Electric Co.

(Continued from page 17A)

of the Task Committee which is composed of: Brooks Chassaing, Midwestern RVP; J. M. Chorlton, Canadian RVP; G. F. Dean, General Secretary; C. D. Miller, East Central RVP; J. D. Mitchell, Director, M. N. Waterman, a past president of IES and J. D. Whitnell, Director.

Two New Chapters Chartered In Louisville, Ky.; Moncton, N. B.

At recent meetings of the IES Council and Council Executive Committee, action was taken to grant charters for two new IES Chapters, Northumberland (Chapter number 92) and Kentuckiana (93).

At its February 12 meeting, on the petition of John M. Chorlton, Canadian Regional Vice-President, Council approved the request for charter from the Northumberland Chapter in Moncton, N. B. This group, sponsored by the Maritime Chapter, St. John, N. B., has as its territory, Moncton, Prince Edward Island and the North Shore of New Brunswick.

Max L. Higgs, The T. Eaton Co., was elected Chairman of the Northumberland Chapter, with Sifroi LeBlanc, Acadia Electric Co., Vice-Chairman; Benoit Lavigne, Tri Electric Co., Secretary-Treasurer; and Wilfred McElman, Franke Levasseur & Co., Ltd., member of the Board of Managers.

Kentuckiana Chapter, developed from the Kentuckiana Lighting Forum in Louisville, Ky., was granted its charter at the March 8 meeting of Council Executive Committee. This chapter, sponsored by the Ohio Valley Section, held four technical meetings prior to petitioning for a charter and boasts a membership of 35.

Chairman of Kentuckiana Chapter is Louis A. Bulleit, E. R. Ronald & Associates; Vice Chairman, William Branham, The Brecker Co.; Secretary, Joseph Howard, General Electric Co.; Treasurer, Art Pickens, Sylvania Electric Products, Inc.

Kentuckiana Chapter will be part of the Great Lakes Region.

Montreal Electrical Club Host to IES President Browder

IES President, Joe B. Browder journeyed to Montreal on February 12 to address a special joint luncheon meeting of the Electrical Club of Montreal and the Montreal Section of IES. Over 250 members and guests in attendance at the meeting in the Queen's Hotel heard Mr. Browder's talk on a subject of very current interest—heating with light—with details of his recent experience in the application of this principle in a new 22-story office building in Atlanta, Ga.

Following the luncheon meeting, Mr. Browder spoke at a residential lighting forum sponsored by the Montreal Section. Other speakers at this residential meeting included L. J. Adams, Canadian General Electric Co. district engineer; Miss Margaret Lidstone, home lighting specialist with the Canadian G-E Lighting Institute in Toronto and Bernard Monaghan, Peerless Electric Co.

EEI Announces Revision of Lighting Demonstration Catalog

The Commercial Lighting Committee of the Edison Electric Institute has recently completed a revision of their "Catalog of Lighting Demonstration and Exhibit Materials." Designed to aid in the planning of effective lighting demonstrations, the catalog includes illustrations and descriptions of various materials useful in group demonstrations. In most cases the catalog materials can be rented or purchased from EEI, but dimensional information and detailed drawings of many of the items, permit the potential user to construct his own equipment.

Price of the catalog to EEI member companies is $2.00; to non-member and foreign companies, $3.00. Orders should be sent to EEI Sales Division, 750 Third Avenue, New York 17, N. Y.

Fellowships Offered for Engineering Design Center

Highly qualified graduate students in several engineering disciplines — civil, electrical, mechanical, chemical and metallurgical—will be offered the opportunity to participate in the new Engineering Design Center at Case Institute of Technology, Cleveland, according to a recent announcement by Dr. James B. Restwick, Director of the Center.

The Design Center is an inter-departmental research and development laboratory concerned with complex systems involving a wide variety of physical elements—electrical, mechanical, pneumatic and hydraulic—often in combination with living elements. Several laboratories already at Case will become parts of the Center; others will associate with individual design projects.

Design teams are formed to establish a program of research and/or development so that the creative performance of each individual may be enhanced. Teams are composed of a project supervisor (faculty member from the professional department), design associate, project engineer, Engineering Design Fellows, students assistants, technical associates and technical assistants.

The Engineering Design Fellows, who form the main body of the design teams, are candidates for Ph.D. or M.S. degrees.

(Continued on page 22A)

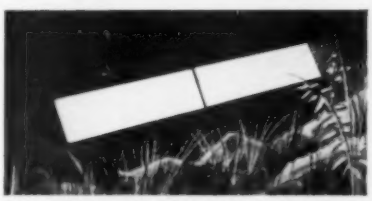
Sylvania **controlled** fluorescents win contract to light Panama Canal's famed Gaillard Cut!

In the Panama Canal's critical Gaillard Cut, other lighting systems tested reflected on the water, blinding ship pilots who strained to see the banks.

Sylvania beat competition by lighting the *banks*, not the water! With low mounting, sharp definition—no reflections! Pilots can see perfectly. Now at last, in the Gaillard Cut, ships can pass in the night!

Sylvania used VHO Reflector power tubes, 8 feet long, delivering the greatest reflected brightness of any fluorescent made! Standing 65 feet apart in Sylvania-developed CFR (Controlled Fluorescent Reflectance) mounts, they throw an unbroken white wall of light up the embankments.

This is just one more example of how Sylvania lighting engineers work to give you superior lighting at lowest possible TCL (Total Cost of Lighting), which means cost of lamp plus power plus maintenance. As a result Sylvania gives every user an exclusive Light Insurance Policy *guaranteeing* more light at lower cost than other brands—or your money back!



Sylvania-developed VHO-CFR system used in Panama Canal, also on airfields, billboards, in industry.

• • •

The Panama Canal Co. enjoys this insurance. Do you? Call your Sylvania representative, or write us: *Sylvania Lighting Products, a Division of Sylvania Electric Products Inc., 60 Boston St., Salem, Mass. In Canada: Sylvania Electric (Canada) Ltd., P. O. Box 1190, Station "O," Montreal 9.*

SYLVANIA

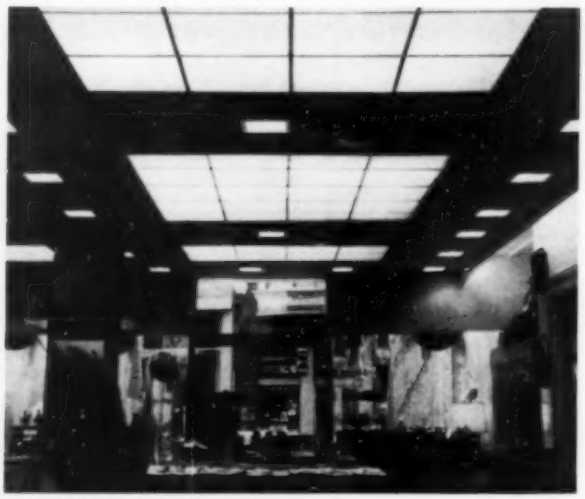
Subsidiary of **GENERAL TELEPHONE & ELECTRONICS**

FIBERGLAS POLARIZING

CHICAGO, Ill. Continental Illinois National Bank & Trust Co. of Chicago. Architect: Graham, Anderson, Probst and White. Fixture Manufacturer: Lighting Dynamics, Inc. Electrical Engineer: Samuel R. Lewis & Associates.

TETERBORO, N. J. Bendix Aviation Company. Engineer/Designer: Stanley R. Bessler with cooperation of Fred DeAngelis, Plant Engineer. Fixture Manufacturer: Sylvania Electric Products, Inc.

PHILADELPHIA, Pa. Lewis Tower Building. Architects: Louis & Henry Magaziner, and Jack Press, Jr. Designer/Decorator: Wanda Norstrom. Fixture Manufacturer: Lithonia Lighting Products Co.



NEW ORLEANS, La. Roosevelt Hotel, Sutton's Linen Shop. Designer/Decorator: J. M. Ber, New Orleans, in conjunction with New Orleans Public Service Lighting Division. Fixture Manufacturer: Luminous Ceilings, Inc.

The Fiberglas* Polarizing Light Panel, developed, produced and sold nationally by Owens-Corning Fiberglas after a thorough test marketing period, is now being used successfully by many of the country's leading fluorescent fixture manufacturers. It is now establishing itself as the modern, attractive way to increase lighting effectiveness.

A few of many successful installations are shown above.

Fiberglas Polarizing Light Panels provide for high levels of illumination, evenly distributed, glare-controlled light in a single panel which attractively complements all ceiling treatments.

Fiberglas Polarizing Light Panels combine the two most desirable properties in lighting—the cut-off of direct glare, which up to now has been accomplished by a lens or

LIGHT PANELS

NOW PROVED-IN-USE!

UPPER DARBY, Pa. Liberty Real Estate Bank. Architect: George M. Ewing Co. Fixture Manufacturer: Keystone Electric Mfg. Co. Lighting Engineer: Francs A. Tahner.

PITTSBURGH, Pa. Pittsburgh Airport Air Traffic Computer Room: Electronic Engineer, Hugh McEvoy. Fixture Manufacturer: Sylvania Electric Products, Inc.

BOSTON, Mass. Travelers Insurance Co. Building. Architects: Kahn & Jacobs. Fixture Manufacturer: Sylvania Electric Products, Inc. Electrical Engineer: Jaros, Baum & Bolles.

MARIETTA, Ga. Lockheed Aircraft Corp., Georgia Division Plant. Architect: Aeck & Associates. Fixture Manufacturer: Day-Brite Lighting, Inc. Electrical Engineer: Walter H. West & Associates.

louver, and the reduction of reflected glare that was previously made possible by a diffuser.

For complete descriptive literature, write:
Owens-Corning Fiberglas Corporation,
Dept. 227-D, 717 Fifth Avenue, New York 22, N.Y.

OWENS-CORNING
FIBERGLAS
T.M. REG. U.S. PAT. OFF.

*T.M. (Reg. U.S. Pat. Off.) O-C.F. Corp.

(*Continued from page 18A*)

Fellows may take up to six credits of course work per term, dividing the remaining time between teaching and working on the design project. Each Fellow receives a yearly stipend commensurate with the responsibility he assumes, but not exceeding $3000 plus tuition. Academic credit is given for course work and for participation in research and development which leads to a thesis.

During the coming year, the first full year of the Center's operation, opportunities will be offered to 15 Fellows.

Comprehensive Education Program Conducted by Florida Section

Not the least of the functions of IES is the dissemination of lighting knowledge to the public and in this phase of Society activity, the Florida Section's education program, in the form of two lighting schools conducted concurrently in Tampa and Sarasota, is notable. In Tampa, the Fifth Annual Lighting School started on March 2 with 100 registered. To run for six consecutive weeks, the school is jointly sponsored by the Tampa Electric Co., Tampa Electrical Contractors Association and the Florida Section. As in past years, the school is guided by the energetic direction of James A. Banton, a recent Southeastern Regional Vice-President and, in many ways, "Mr. IES" in his home area.

Sarasota's first lighting school began on March 1 under the direction of Kenneth Brumbaugh consulting engineer and Chairman of the Florida Section. Forty-two attended. In addition to IES, sponsors of this school include the Florida Power and Light Co., Sarasota-Manatee Electrical Contractors Association and the Sarasota Vocational School (a unit of the city's adult education program).

Opening speaker for both courses was Dick Slauer, First Vice President of IES, who instructed in lighting design fundamentals. Other topics to be covered in the Tampa course include office and store lighting, residential lighting, luminous ceilings, maintenance, ballasts and exterior lighting. In Sarasota, following the session on fundamentals of illumination, the instruction will be in residential lighting, light sources, commercial lighting and floodlighting.

IES Technical Forum to Study Application of Research Findings

With the lighting industry still trying to bring practice in line with the research results reported by Dr. H. Richard Blackwell and the implications of researches reported at the recent IERI Symposium (see page 7A), there is an urgent need for solving engineering application problems presented by basic research findings. Recognizing this as a responsibility of IES, Richard G. Slauer, IES First Vice President, in charge of the Society's technical program, has spearheaded the organization of an informal technical forum to be held at Wilson Lodge, Oglebay Park, Wheeling, West Virginia, April 25 and 26.

The forum is not intended to be a major IES conference but an informal meeting of members of IES committees for the discussion of engineering and application factors related to the results of current basic research, with particular emphasis on interior lighting design and the problems of illumination levels, glare and brightness. Theme of the meeting is the review of responsibilities and problems confronting the lighting engineer in the acceptance and recommendation of higher illumination levels. Four sessions have been planned, to consider illumination levels, reflected glare, brightness balance and direct glare.

To stimulate discussion, it is hoped that each registrant will come to the forum with a five-minute commentary on a particularly salient topic.

For motel arrangements, members should contact Mr. Slauer at Sylvania Electric Products, Wheeling, West Va.

Willard C. Brown Retires, With G-E for 40 Years

Willard C. Brown, a Past President (1940-1941) and Fellow of IES, retired on March 31 from his position as manager of Lighting Education with the General Electric Co., Nela Park, Cleveland. Mr. Brown, who received degrees in electrical engineering from Virginia Military Institute, Massachusetts Institute of Technology and Harvard University, joined the company in 1920. In his 40 years of association with G-E he was active in a variety of lighting fields including automotive, electrical advertising, theatre, farm, school and industrial. In 1948 he was named Manager of Application Engineering and in 1957 became Manager of Lighting Education.

A long-time member of IES (he joined in 1923), Mr. Brown's Society activities include six years as Chairman of the Progress Committee and Vice Chairman of the Committee on Lighting Practice during the time this committee developed the "Recommended Practice of Industrial Lighting" and the "American Standard Practice of School Lighting." He was also Chairman of the Finance Committee.

As first Chairman of the Lighting Committee of the American Society of Agricultural Engineers, he was responsible, in large measure, for the development of the first bulletin on farm lighting. He has authored many technical papers presented before IES and other professional groups.

Willard C. Brown

Mr. Brown is a prominent figure in international lighting activities, too, having served as Director of the Secretariat on Lighting Practice at the CIE meetings in 1939, 1948 and 1951. Currently he is President of the United States National Committee of CIE.

In addition to his lighting activities, Mr. Brown is a member and Past President of the Cleveland Engineering Society and holds the rank of Captain in the retired list of the United States Naval Reserve.

Succeeding Mr. Brown as Manager of Lighting Education at General Electric is Kirk M. Reid (see item page 25A), another Past President of IES.

Obituary

Lester H. Graves, a Past President and Fellow Emeritus of IES, died on December 31, 1959 in Santa Barbara, Calif., after a brief illness. In tribute to Mr. Graves, the IES Council stood in one minute of silence at its February 12 meeting.

Mr. Graves graduated from the University of Illinois in 1912 with a B.S. in electrical engineering and spent all but one year of his business career with Curtis Lighting, Inc. When he retired from Curtis in 1950 he held the position of Vice President in charge of Eastern Operations.

During his career in illuminating engineering, Mr. Graves was identified with many prominent lighting installations including Temple Emanu-el, Church of the Heavenly Rest and special lighting for the Waldorf Astoria Hotel, all in New York City. He was also associated with the lighting design for the Commons Chambers in the Parliament Buildings in Ottawa, Ont. and the louvered installations of the Woolworth Co. throughout the United States. He presented numerous technical papers on lighting practice at the National Technical Conferences of IES.

(*Continued on page 25A*)

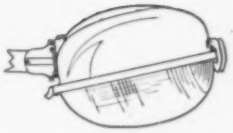
Revere Outdoor Lighting Report

Revere ELECTRIC MFG. CO.

Lighting a city street

The Problem: To illuminate a wide city street uniformly across the total width with high-level light, thus providing fast-moving traffic with utmost visibility for safety.

The Solution: Revere Endoval Luminaires with 400-watt mercury lamps were mounted at 10° tilt on both sides of the wide street, staggered. Distribution pattern selected was I.E.S. Type III which provided uniform light across the entire width of the street, giving the high visibility desired for safe, smooth traffic flow. There is adequate spill light to illuminate sidewalks and parked cars. Endovals mount horizontally if desired.

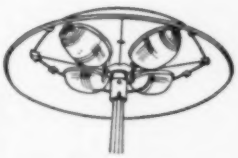


No. 2200 Series
Endoval Luminaire

Lighting a shopping center parking lot

The Problem: To provide high night-visibility for a large shopping center parking lot for ease and safety in driving, parking, and locating parked cars, and to make the shopping center more inviting.

The Solution: High-level, uniform lighting was achieved with 187 Revere 72-inch diameter Ultra-Lites, mounted 34 feet above grade. They use four E-H1 400-watt mercury lamps each, positioned for widest coverage and highest illumination level. Ultra-Lites throw square light patterns which overlap to eliminate "dark spots" and to build up light values in fringe areas.

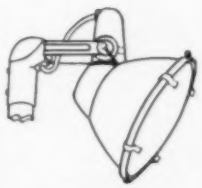


No. 5442 Ultra-Lite

Lighting a flight line

The Problem: To illuminate the wide expanse of a flight line so that routine aircraft operations could be carried on at night with complete convenience and safety.

The Solution: To light the broad flight line intensely and uniformly, 1800 Revere Alzak Aluminum Enclosed Floodlights were used. They were mounted on thirty 80-foot poles, each pole having two banks of 30 floodlights. Each bank has 12 wide-beam floodlights (No. 4211-P) and 18 narrow-beam floodlights (No. 4216-P), with 1500-watt P.S. 52 clear, general-service lamps.



No. 4200
Series Floodlight

Write for Revere's complete catalog of outdoor lighting equipment.

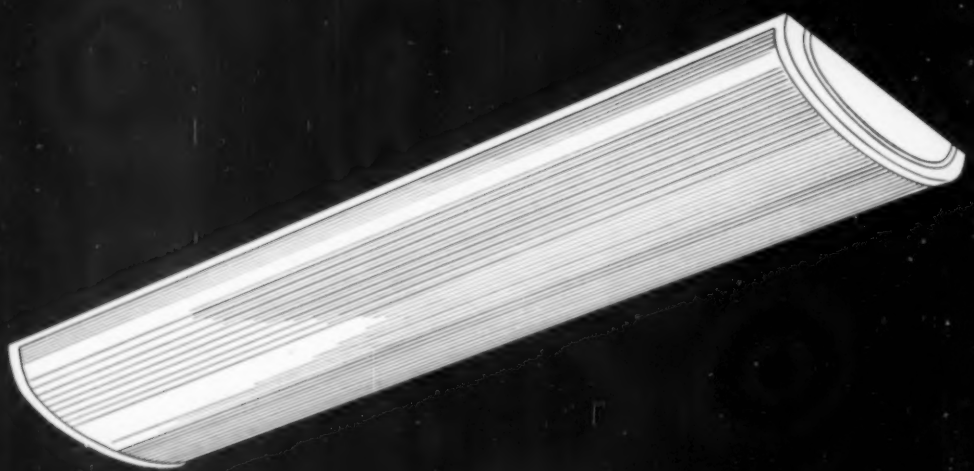
Revere ELECTRIC MFG. CO.

OUTDOOR LIGHTING

Revere Electric Mfg. Co. • 7420 Lehigh Avenue • Chicago 48, Illinois (In suburban Niles)
Long Distance Phone: NIles 7-6060 • Chicago Phone: SPring 4-1200 • Telegrams: WUX Niles
In Canada: Curtis Lighting, Ltd., Leaside, Toronto, Ontario

Ultra-Lux...distinctive style and performance
in ultra-shallow two or four-lamp units

Send for brochure **GARCY LIGHTING** DIV. OF GARDEN CITY PLATING & MFG. CO.
2475 ELSTON • CHICAGO 47, ILLINOIS



(Continued from page 22A)

Mr. Graves joined IES in 1914 and transferred to Member grade in 1916. His many years of active service to the Society included, in addition to his 1939-1940 term as President, three years as General Secretary (1925-1928), three years as Director, a year as Treasurer and two years as Vice President. He was Chairman of the Committees on Finance, Revision of the Constitution and By-laws, Light in Architecture and Decoration, Local Activities and the IES Prize Committee.

In addition to his executive responsibilities with Curtis and IES, Mr. Graves also counted among his accomplishments the Mayoralty of Pelham Manor, N. Y.

Even after his retirement, Mr. Graves continued his interest in IES, attending every National Technical Conference of the Society, most recently the 1959 Conference in San Francisco.

1960 Regional Conferences—IES

Region	Date and Place	Chairman
South Central and Southeastern	April 21-22 Peabody Hotel Memphis, Tenn.	J. F. Fletcher Standard Electric Co. 876 Vance Ave. Memphis, Tenn.
Southwestern	April 25-26 Robert Driscoll Hotel Corpus Christi, Texas	B. L. Guess, Jr. 1210 York Ave. Corpus Christi, Texas
Inter-Mountain	April 28-29 Mountain Shadows Resort Scottsdale, Ariz.	D. L. Ruff Arizona Public Service Co. Phoenix, Ariz.
South Pacific Coast	May 3-5 Hollywood Roosevelt Hotel Hollywood, Calif.	William Shalda Shalda Mfg. Co., Inc. P. O. Box 507 Burbank, Calif.
Pacific Northwest	May 9-10 Benjamin Franklin Hotel Seattle, Wash.	G. D. King Sylvania Electric Products 3466 E. Marginal Way Seattle, Wash.
Midwestern	May 12-13 Sheraton-Martin Hotel Sioux City, Ia.	Mark Lee and C. R. Tracy Iowa Public Service Co. Sioux City, Ia.
Great Lakes	May 16-17 Carter Hotel Cleveland, Ohio	R. D. Churchill General Electric Co. Nela Park, Cleveland, Ohio
Northeastern	June 8-9 Wentworth-By-the-Sea Portsmouth, N. H.	C. M. Holden Vorlander Lighting 80 Boylston St. Boston, Mass.
Canadian	June 13-14 Nova Scotian Hotel Halifax, N. S.	Henry Lushington Canadian G-E Co. Halifax, N. S.

ABOUT PEOPLE

Kirk M. Reid has been named Manager of Lighting Education for the General Electric Large Lamp Department, Nela Park, Cleveland, replacing **Willard C. Brown** who retired on March 31 (see item page 22A). In his new capacity, Mr. Reid, a Past President (1957-1958) of IES, will be responsible for the operation of the Lighting Institute at Nela Park and for lighting education programs designed for various consumer, technical, civic and professional organizations. A veteran of 40 years with General Electric, Mr. Reid served in plant engineering, technical writing, street, highway, sports lighting and building floodlighting departments with the company. In 1957 he became supervisor of the photometric and lamp performance laboratories and most recently has been supervisor of lighting application in the industrial, commercial and residential fields.

Several new appointments have been announced by Sylvania Lighting Products, a division of Sylvania Electric Products Inc. **Frederick H. Heintz** has been named vice-president — marketing, Large Lamp Products, with headquarters in Salem, Mass. In his new position, Mr. Heintz will be responsible for marketing programs for incandescent, fluorescent and mercury vapor lamps. **Robert L. Kleinfeld,** general marketing manager—photolamps since last October, has been promoted to vice-president — marketing, photolamp and special products. Working out of New York City, he will continue to direct Sylvania's marketing efforts in the photolamp and special lighting products fields. **Walter K. Anderson** has been named manager of equipment development and **L. John Doyle** has been appointed Midwest regional sales manager. Mr. Doyle will be responsible for all marketing programs in the midwestern region with headquarters in Chicago. **Roland M. Gardner,** manager of equipment development who retired March 1 after 41 years with the company, will continue to serve Sylvania as a consultant. Sylvania Electric Products Inc. announced the appointments of **Terry P. Cunningham** as director of advertising production and **Edward L. Slater** as director of advertising. Mr. Cunningham lists among his new duties the coordination of plans and production of advertising and sales promotion materials for the corporation. Mr. Slater, who succeeds Mr. Cunningham, will be responsible for corporate advertising programs.

The Engineering Institute of Canada has announced the election of **George McKinstry Dick,** M.E.I.C., of Sherbrooke and Montreal, Que., as president for 1960-1961. Mr. Dick, who is scheduled to be installed at the Institute's 74th annual meeting in May, is chief engineer for the Canadian Ingersoll-Rand Co. Ltd., which company he joined in 1915. He will succeed **J. H. Hanna,** M.E.I.C., of Calgary, Alberta.

Frank H. Roby, executive vice-president, Federal Pacific Electric Co., has been elected chairman of the newly organized Building Equipment Division of the National Electrical Manufacturers Association. Formation of the division is another step in plans which were approved late last year to reorganize the Association.

The election of **William F. Kelley,** president, Motion Picture Research Council, Los Angeles, Calif., to the Board

(Continued on page 26A)

PANELISTS who sparked lively discussion on "The Ambiguous Instruction" at a recent meeting of the Edmonton Section, left to right: Ewart Haacke, manufacturer's representative for J. A. Wilson Lighting and Display Co.; Neil Longson, Northwestern Utilities; Ron Grantham, panel moderator; Al Robertson, Crowther McKay & Associates, consultants; Ridge Young, electrical contractor.

(Continued from page 25A)

of Governors of the Society of Motion Picture and Television Engineers, was announced by SMPTE secretary Wilton R. Holm. Mr. Kelley is a Fellow Member of the Society.

Several personnel changes have been made in the IES Philadelphia Section administration, effective February 16. **William G. Speed** of Hopkin Bros., Inc., has been appointed vice-chairman to replace the previously elected **Edwin H. Henrie,** who was transferred to the Wilmington office of the H. P. Foley Co. **E. Fred Bahls** of Philadelphia Electrical & Manufacturing Co. is now chairman—Dinner-Dance Committee. **William B. Beggs** of Westinghouse Electric Corp. has resigned as a member of that committee since his transfer to Baltimore as district manager.

The General Electric Co., Cleveland, Ohio, has announced two new appointments in the Miniature Lamp Department. **Albert F. Brun** has been named manager—Replacement Lamp Sales, and **Gomer F. Davis** is the new marketing manager. Mr. Brun, operating out of company headquarters at Nela Park, will be responsible for all phases of the planning, promotion and sales of replacement lamps while Mr. Davis will oversee all facets of the department's marketing operation. Also announced was the appointment of **George S. Trotter** as manager of the western sales region of G-E's Large Lamp Department. Formerly manager of the department's Buckeye sales district, Mr. Trotter will now be responsible for the sale of G-E general lighting lamps for industrial, commercial and residential use through five sales districts, with headquarters in Portland, Ore. He replaces **Donald D. Scarff,** who recently was named general manager of the department. New manager of the Buckeye sales district will be **Harold E. Bentz,** who has been manager of the department's Puget Sound sales district.

Robert L. Zahour, a Fellow of IES, has been named manager of lamp applications for the Westinghouse Lamp Division, according to an announcement by Marshall N. Waterman, manager of large lamp commercial engineering. In his new position Mr. Zahour, working closely with lighting fixture manufacturers, consulting engineers and architects on various lighting techniques and developments, will be responsible for keeping these groups abreast of the latest lamp products. He will also be responsible for developing new lighting applications and will lecture on these subjects before technical society groups. Mr. Zahour will make his office at Lamp Division headquarters in Bloomfield, N. J.

Russell E. Owen has been appointed manager of marketing service for Day-Brite Lighting, Inc., St. Louis, Mo. Formerly a sales manager for the Curtis Lighting Division of Curtis-AllBrite Lighting, Inc., Chicago, Ill., Mr. Owen will be responsible for marketing activities, including advertising, sales promotion and public relations. Also announced was the addition of two sales representa-

(Continued on page 31A)

PLANNING for the Southeastern-South Central Regional Conference, to be held in Memphis, Tenn., April 21 and 22, Glenn McMullen (left) and Charles Hooper, members of the host Mid-South Chapter, visit Edison Park, one of Memphis' points of interest for IES members who will attend the Conference. On the conference technical program are talks on high frequency lighting, the quartz lamp and the problem of "bland environments."

LASTING QUALITY for your CLIENTS!

Smooth, uninterrupted lines — free of bolts, hinges and all visible hardware.

Interlocking door frame provides positive light seal.

Framed in the ceiling by a narrow metal band.

Maximum illuminated areas, softly diffused illumination.

Easily installed with time-saving mounting brackets, double-fast screws.

Four basic types fit 101 ceiling systems.

Your choice of 12 shielding media.

Available in one and two-foot widths.

Write to Smithcraft for illustrated catalog and price list of Smithcraft Speedomatic Troffers.

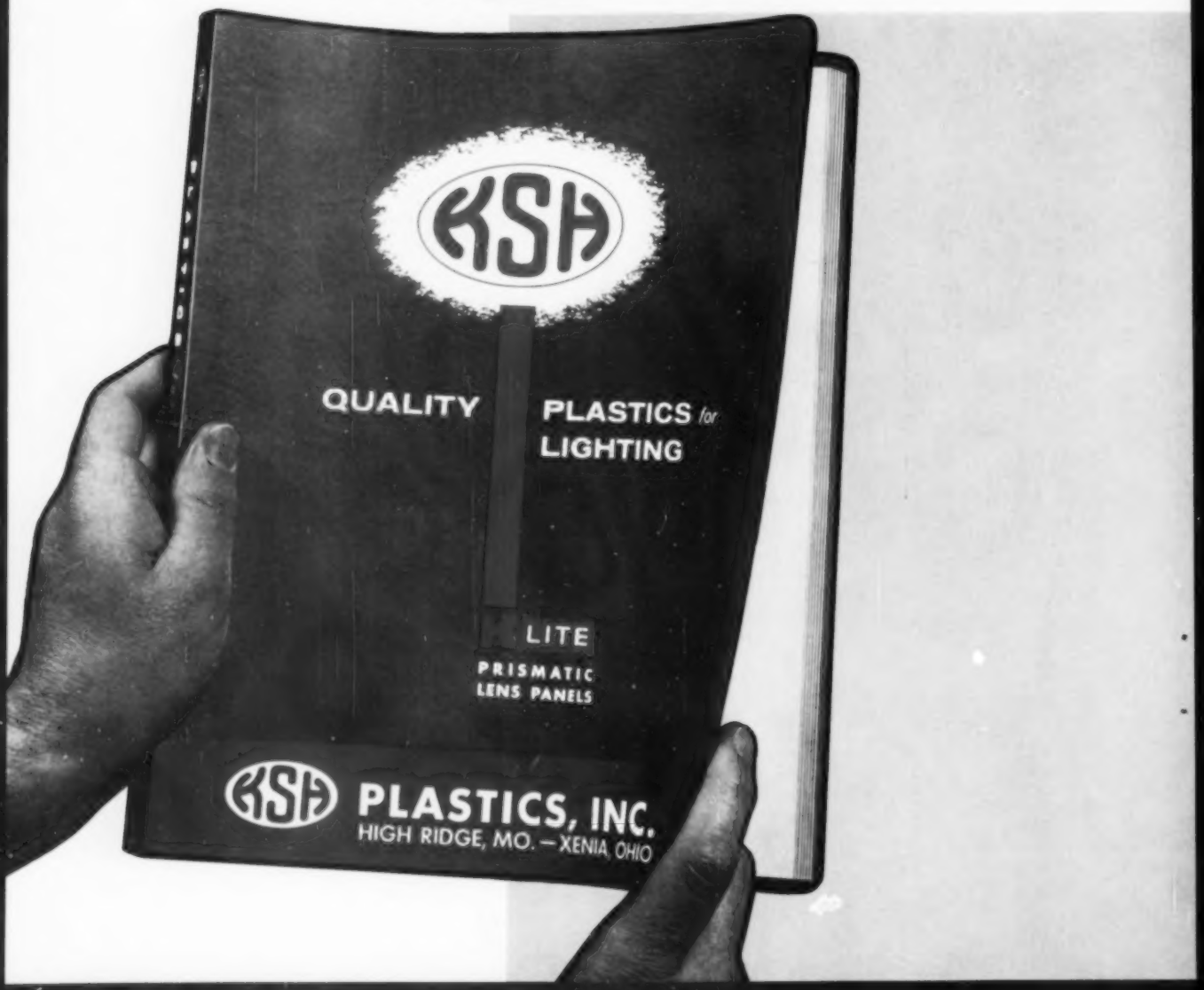
Smithcraft SPEEDOMATIC TROFFERS

Light-conditioning by Smithcraft—America's finest fluorescent lighting

Smithcraft
LIGHTING
CHELSEA 50, MASSACHUSETTS

NEW Comprehensive Plastic

FEATURING THE MOST COMPLETE LINE OF QUALITY EXTRUDED PLASTICS FOR LIGHTING . . . including KLITE® Prismatic Lens Panels



KSH® PLASTICS, INC.

PIONEERED ENGINEERING FOR SUCCESSFUL EXTRUSIONS

Lighting Catalog from K-S-H®

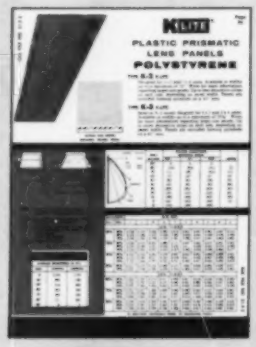
FEATURING THE MOST COMPLETE PLASTIC CATALOGING SYSTEM AND HELPS FOR ARCHITECTS, ENGINEERS AND LIGHTING SPECIALISTS

INDEXING

New from K-S-H complete indexing system for your files including AIA File Numbers.

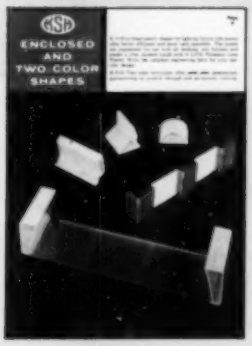
K-LITE FACTS ABOUT K-LITE PRISMATIC LENS PANELS

The advantages of K-S-H extruded plastic prismatic lens panels are clearly illustrated.



PHOTOMETRIC DATA

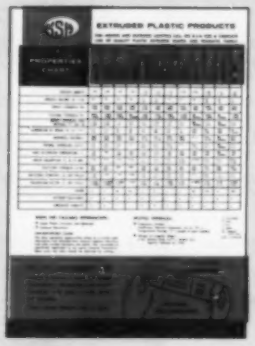
Complete engineering for each lens, both polystyrene and acrylic are clearly charted for fast, accurate figuring.



LENS PANELS LENS SHAPES

- ENCLOSED
- TWO-COLOR
- EXTRUDED SHAPES

Complete illustrations showing tremendous versatility of K-S-H extrusion methods.



PROPERTIES CHART

Handy, convenient properties chart gives all technical facts from specific volumes to dimensional stability for all types of plastics.

PANEL AREA CALCULATOR

. . . Your's for the asking. Quickly and accurately determines lens panel square footage necessary for any fluorescent lighting job.

REPRESENTATION IN:

ATLANTA • CHICAGO • DAYTON
DETROIT • GRAND RAPIDS • INDIANAPOLIS • LOS ANGELES
MILWAUKEE • ST. LOUIS • SALEM (MASS.) • SAN FRANCISCO

Export:
ROLDAN PRODUCTS CORPORATION, ST. LOUIS

Home Office:
HIGH RIDGE, MISSOURI

Plants In:
High Ridge, Missouri
and Xenia, Ohio

SEND FOR MORE INFORMATION

K-S-H PLASTICS, INC.
High Ridge, Missouri, Dept. IE-60

☐ Please send more information regarding your new complete cataloging system.

☐ Please have your representative call on our firm. We need immediate expert advice on fluorescent lighting lens panels.

Name _____

Title _____

Company _____

Address _____

City _____ Zone ____ State _____

This Bank Gets a Public Relations Bonus For Its Lighting Equipment Money

When a bank's customers become vocal in their appreciation of the new lighting, that's good public relations. When the bank itself is pleased by both the lighting and customer response, that's good business!

This is a remodelling installation. Most impressive is the border of the luminous ceiling which has an upward slope of 30°, giving a picture frame or 3-dimensional effect* — a handsome choice for calling attention to the detail in the handsome frieze adjacent.

More practically, the intensity on the Tellers' Cage is now 100 foot-candles, average before was 5. If desired, intensity can be doubled by adding a row of lamps between existing rows. The equipment provides 45° shielding crosswise and lengthwise while diffusing the working plane with light. Light in weight, aluminum louvers save on installation expense and reduce the weight of the lighting system.

For *similar* results with standard, cost-saving equipment, specify Litecontrol.

** This modification of the Litecontrol standard ceiling is purely decorative.*

INSTALLATION:
City Trust Company, Bridgeport, Connecticut
ENGINEERING CONSULTANT:
Clark Lighting Services, Waterbury, Connecticut
ELECTRICAL CONTRACTOR:
Eastern Electrical Construction Company, Bridgeport, Connecticut
DISTRICT SALES ENGINEER FOR LITECONTROL CORPORATION:
Harold R. Young, 6 Pratt Street, Rocky Hill, Connecticut
AREA: Banking Area and Public Area
CEILING HEIGHT: 24'-6"
PLENUM DEPTH: 2'-6"
LUMINOUS CEILING:
2' x 4' white enamel finished aluminum louvers, ⅜" cube on aluminum inverted T-bars. 40 watt Rapid Start Lamps, 24" on centers, mounted on Kindorf channel.
INTENSITY: On Tellers' Cages, 100 foot-candles in service.

LITECONTROL
Fixtures
KEEP UPKEEP DOWN
LITECONTROL CORPORATION,
36 Pleasant Street, Watertown 72, Massachusetts

DESIGNERS, ENGINEERS AND MANUFACTURERS OF FLUORESCENT LIGHTING EQUIPMENT DISTRIBUTED ONLY THROUGH ACCREDITED WHOLESALERS

(Continued from page 26A)

tives: **Hugh T. Dutter, Jr.,** formerly the Detroit sales representative of the Pittsburgh Reflector Co. for 11 years, will work out of Beverly Hills, Calif.; **L. H. Edenfield,** until recently vice-president and sales manager of Stokes Electric Co. in Knoxville, Tenn., will be headquartered in Knoxville.

C. K. Kurtzon, president of Garcy Lighting, a division of Garden City Plating and Manufacturing Co., Chicago, Ill., has named **John Metelnick** as general manager. Mr. Metelnick will direct all operations of the lighting division.

Engineering Products, Indianapolis, Ind., has announced the appointment of **William A. Woods** as general manager. Mr. Woods has been sales manager of the company for the past year.

John F. Kramer has been transferred from the Cleveland office of the Electric Products Division of Vickers, Inc., to the firm's Washington, D. C., headquarters. Mr. Kramer will be the new Washington district manager. **Thomas Orr,** a new addition to the Electric Products Division staff, will take over its Cleveland office operation. Also announced was the appointment of **Frank Hynes** to the post of manager of military sales.

The appointment of **Donald J. Kennedy** as regional sales manager—industrial products has been announced by Hexcel Products Inc., Berkeley, Calif. Mr. Kennedy, with headquarters in Chicago, Ill., will direct marketing of the company's products in that area.

The promotion of **W. A. Dalrymple** to sales manager—Central Zone, has been announced by the Amalgamated Electric Corp., Ltd., Toronto, Canada. In his new position, Mr. Dalrymple will be responsible for the sale of the company's full line of products.

Thatcher Glass Mfg. Co., Inc., Jeannette, Pa., has appointed several new representatives. **W. and L. Sales,** Los Angeles, will represent Thatcher in California, Washington and Oregon. Principals are **Arthur Weingart** and **Jules Lustig.** In Toronto, their representatives will be **Henderson-Oliver Sales Co.;** principals are **C. A. Henderson** and **Tom Oliver.** In eastern Pennsylvania and New Jersey, **Herbert Lomsky** of Philadelphia, and for Ohio, **Dav-Ron and Associates,** with **John Senkyer** as principal.

The newly created position of planning coordinator for the Verd-A-Ray Corp., Toledo, Ohio, has been filled by **Alvin E. Zanter.** Mr. Zanter, formerly a sales engineer for the Garlock Packing Co., N. J., will have as his primary responsibility the coordination of sales, product research and development, manufacturing and personnel programs.

Sun-Lite Manufacturing Co., Detroit, Mich., has announced the appointment of **Carroll Associates, Inc.,** Detroit, as sales agency for their products in Michigan.

The appointment of **B. E. Watson & Associates** as northern Texas and Oklahoma representatives has been announced by Pfaff & Kendall, Newark, N. J. The Watson organization maintains headquarters at Dallas.

Donald F. Moulton has been named representative in New England for the Lighting Sales Department of Corning Glass Works, Corning, N. Y. He will be succeeded in his former position as a lighting salesman for Corning Glass Works of Canada, Ltd., Toronto, by **Donald A. Urquhart,** who recently joined the company. Mr. Moulton will have his headquarters at Reading, Mass.

The Edwin F. Guth Co., St. Louis, Mo., has appointed **Roger E. Bessmer** as their new lighting representative for western Missouri and northern Kansas.

Deaths

Kenneth Curtis, former President, Curtis Lighting, Inc.

R. J. Murphy, New York Section.

L. R. White, Curtis-AllBrite Lighting, Inc., Chicago, Ill.

Joseph M. Smith, Southern California Section.

BOOKS AND PAMPHLETS

American Standard Methods of Determining Areas in Hospitals and Related Facilities, Z65.4—1959, available from American Standards Association, Dept. PR129, 10 East 40th Street, New York 16, N. Y., 50 cents.

Architects, private and government hospital administrators and others concerned with hospital design and administration have developed this standard for measuring the areas of hospitals and related facilities. It includes methods of determining gross area, circulation areas for patients and visitors and departmental areas. These methods will be useful for comparing the areas used for general traffic with those required for the actual operation of a hospital and for checking space to be assigned for use by various hospital departments.

1960 Manufacturers' Agents' Guide, available from the Manufacturers' Agent Publishing Co., 505 Fifth Ave., N. Y., $15.00.

This Guide, which lists more than 11,500 manufacturers who distribute their products through manufacturers's agents, has been prepared in response to requests by "reps" who seek to expand their present lines. Classified by industry and providing a comprehensive listing of manufacturers and their addresses, the directory includes information concerning principal products, estimated credit rating and name and title of sales executive. It also details steps to follow in communicating with manufacturers, suggests commission scales for various products, typical clauses to consider in a manufacturer-manufacturers' agent contract and provides data on operations as an agent.

American Standard Dimensional and Electrical Characteristics of 4-Watt, T-5, Preheat-Start Fluorescent Lamp, C78.400-1959, available from American Standards Association, Department PR 119, 70 East 45th Street, New York 17, N. Y.

The revised standard, covering the small, general-purpose fluorescent lamp used in offices, homes and factories, provides for interchangeability. Operating characteristics of the lamp have been revised, but dimensional characteristics and lamp designation remain unchanged from the previous standard. Also included are sections on starting requirements.

Basic Theorems in Matrix Theory, by M. Marcus, National Bureau of Standards Applied Mathematics Series 57, available from Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C., 15 cents.

With the advent of large digital computing machines, the use of finite matrices of high order has become practical in solving many problems in fluid dynamics, structural mechanics, atomic physics and other fields. This publication, surveying the basic identities and inequalities of matrix theory, is intended as a reference guide for students and research workers. Included are results dealing with elementary properties, canonical forms, invariance, congruence, commutativity, orthogonalization, eigenvalues, determinants, sub matrices, rank, determinant and rank

(Continued on page 32A)

(*Continued from page* 31A)

inequalities, numerical methods for inversion and eigenvalues and condition numbers.

There has been no attempt to provide proofs for the theorems listed. All statements are made directly in terms of matrices rather than linear transformations. References are given after each result.

A New Sales Approach to the Commercial Market, PB-104, available from Commercial Promotion Department, National Wiring Bureau, 155 East 44th Street, New York 17, N. Y.

This booklet has been developed as an aid to advertising and promotion programs coordinated with the "Keep Pace Electrically" program of the National Wiring Bureau. It contains suggestions on how to use the "Keep Pace Electrically" idea for promoting electric living and increased sales and includes a catalog of advertising materials available for tie-ins with the program. Single copies may be obtained on request to the National Wiring Bureau. Additional copies are available for 25 cents plus handling charges.

Sylvania Photographic Lighting, available from Sylvania Electric Products Inc., Department PC, 1100 Main Street, Buffalo, N. Y. No charge.

A guide to photographic lighting products, this 36-page booklet includes technical data and recommendations on flashbulbs, movie lights, flood, enlarger and darkroom lamps and projection lamps. Charts show peaking characteristics of flashbulbs plus listing of guide numbers, synchronization and use information for each lamp. In the projection lamp section, a chart lists projectors by manufacturer and model number and tells which lamp is designed for which projector.

Optics and Spectroscopy, translation of *Optika i Spektroscopiya*, available from American Institute of Physics, 335 East 45th St., New York 17, N. Y., $25 per year.

Aided by a grant-in-aid from the National Science Foundation, the Optical Society of America has begun translation and publication of the Russian journal, *Optika i Spektroscopiya*. One of the leading journals of the USSR Academy of Sciences, this periodical contains reports on the work of Soviet scientists in all branches of optics and spectroscopy including x-ray, ultraviolet, visible, infrared and microwave, thin layer optics, filters, detectors, diffraction gratings, electroluminescence, thermal radiation backgrounds, infrared polarizers and their many applications in science and industry. The journal is being distributed free to members of the Optical Society. Nonmember subscriptions for the package deal of *Optics and Spectroscopy* and *The Journal of the Optical Society of America* are available as noted above.

Building Illumination, The Effect of New Lighting Levels, available from Publications Office, National Academy of Sciences, National Research Council, 2101 Constitution Avenue, N.W., Washington 25, D. C., $5.00.

The proceedings of the Building Research Institute's conference on the new IES recommended levels of illumination as they affect the building industry, are now available in booklet form. Included are Dr. H. R. Blackwell's report on his eight-year researches; C. L. Crouch's explanation of the IES interpretation of the Blackwell research and papers by various recognized experts on the new levels in relation to school lighting, air conditioning and noise control and economies. Also in the booklet are papers on daylighting, light in architecture and light sources.

Copies of these proceedings are available to BRI member organizations at a 25 per cent discount from the list price.

NEW MEMBERS

At the meeting of the IES Council Executive Committee on March 8, 1960, the following were elected to membership. Names marked * are transfers from Associate Member Grade.

ALABAMA SECTION

Member:

Pearce, T. E., Whitman Associates, Warrington, Fla.

ARIZONA SECTION

Member:

*Kiedaisch, Jack, Arizona Public Service Co., Phoenix, Ariz.

ARKANSAS SECTION

Member:

Ellefson, G. E. Jr., Ehrhart, Eichenbaum, Raugh & Blass, Little Rock, Ark.

ARK-LA-TEX CHAPTER

Associate Member:

Claus, R. L., Southwestern Electric Power Co., Texarkana, Ark.

CENTRAL NEW YORK SECTION

Member:

*Crosby, W. F., Corning Glass Works, Corning, N. Y.

Associate Member:

Mahaffy, W. C., Gould-Farmer Co., Inc., Syracuse, N. Y.

CENTRAL OKLAHOMA CHAPTER

Member:

*Rodesney, Frank, Benham Engineering Co., Oklahoma City, Okla.

CHICAGO SECTION

Members:

Dunn, D. E., The Compco Corp., Chicago, Ill.

*Pearson, P. O., Ragnar Benson, Inc., Chicago, Ill.

Associate Members:

Bean, H. H., Chicago Electrical News, Chicago, Ill.

Lessner, R. C., Benjamin Electric Mfg. Co., Des Plaines, Ill.

Serio, Pasquale, Benjamin Electric Mfg. Co., Des Plaines, Ill.

CLEVELAND SECTION

Members:

Gabriel, Monroe, General Electric Co., Nela Park, Cleveland, Ohio.

*Gaetjens, A. K., General Electric Co., Nela Park, Cleveland, Ohio.

*Kolb, W. S., Westinghouse Electric Corp., Cleveland, Ohio.

Koth, H. E., General Electric Co., Nela Park, Cleveland, Ohio.

*Leighton, Kaye A., General Electric Co., Nela Park, Cleveland, Ohio.

*Page, Aileen M., General Electric Co., Nela Park, Cleveland, Ohio.

Associate Members:

Adache, W. M., Adache Associates, Inc., Engineers, Cleveland, Ohio.

Chick, R. W., Arthur G. McKee Co., Cleveland, Ohio.

Neal, O. T., General Electric Co., Cleveland, Ohio.

Nottage, D. R. Sr., General Electric Co., Nela Park, Cleveland, Ohio.

Stuart, C. J., General Electric Co., Cleveland, Ohio.

COASTAL BEND CHAPTER

Member:

*Gilbert, P. O., Central Power & Light Co., Victoria, Texas.

CONNECTICUT SECTION

Member:

*Waite, R. T., Aetna Casualty & Surety Co., Hartford, Conn.

Associate Members:

Altieri, J. L., John L. Altieri, Consulting Engineers, S. Norwalk, Conn.

Arnold, Douglas, The Miller Co., Meriden, Conn.

Danforth, R. A., Hartford Fire Insurance Co., Hartford, Conn.

Everest, R. F., Spring & Buckley, Inc., New Britain, Conn.

Krug, R. A., Modern Lighting Service Co., New Canaan, Conn.

Santella, P. M., Peter M. Santella Co., New Canaan, Conn.

Seeley, F. P., Technical Electric Sales Associates, W. Hartford, Conn.

EASTERN NEW YORK SECTION

Member:

*Rice, R. H., Westinghouse Electric Corp., Albany, N. Y.

EASTERN PENNSYLVANIA SECTION

Member:

*Schaeffer, G. H. Jr., The Carpenter Steel Co., Reading, Pa.

FOREST CITY (LONDON) CHAPTER

Member:

Thomson, J. L., Lighting Maintenance Service, Windsor, Ont.

GEORGIA SECTION

Member:

*Ferry, A. L., Alan L. Ferry Designers, Atlanta, Ga.

GOLDEN GATE SECTION

Member:

*Patton, L. E., 604 Mission St., San Francisco, Calif.

(*Continued on page* 62A)

TWO QUESTIONS:

1. Who'll throw out the first baseball at Griffith Stadium in 1962?

2. How many fluorescent lamps (installed this month) will <u>your</u> <u>customers</u> throw out by opening day, 1962?

As for question number one, traditionally the President opens the baseball season in Washington by tossing out the first ball. Who he'll be, we don't know. Sorry!

But we *do* know something about question number two. If a customer installs General Electric Fluorescents this month, *about 99% of them will still be going strong when the 1962 season opens!* That's because G-E Lamps are built and tested to give far fewer early burnouts. Records show that, on the average, G-E Lamp users will have between 1-2% burnouts after two years of single shift, or daytime, service. So, there are fewer work interruptions, fewer expensive, one-at-a-time lamp replacements. And the lighting level stays higher, longer because of G-E improvements.

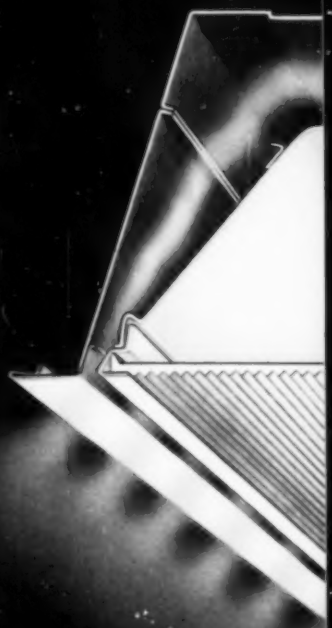
G-E Lamps can save your customers money. Whether they use 40-watt, high output or slimlines, there's a G-E Money Saver Lamp that's just right for the job. And even bigger savings if they install a new system with G-E Power Groove® Lamps—the most powerful fluorescent they can buy. Ask your G-E Lamp representative for expert lighting advice—or write: General Electric Co., Large Lamp Dept. C-017, Nela Park, Cleveland 12, Ohio.

Progress Is Our Most Important Product

GENERAL ELECTRIC

General Electric... where bright ideas become better lamps

COMFORT CONDITIONING . . . . . .



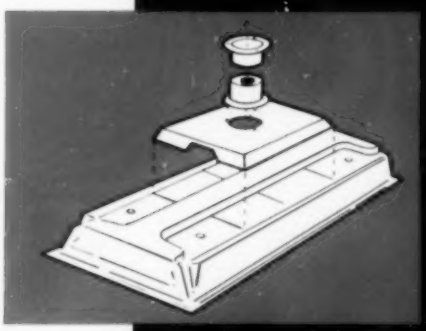
Comfort Conditioning . . . with Light and Air . . . is the result of the combined research and engineering know-how of Day-Brite Lighting, Inc. and the Barber-Colman Company.

The successful blending of these two prime comfort factors, provides the much needed solution to a growing problem in interior design . . . the competition between acoustical material, air distribution, and lighting elements.

Trim, functional design, combined with the finest in comfort lighting and air distribution.

Two basic sizes, 12" x 48" and 24" x 48" . . . a wide choice of lighting enclosures . . . louvers, plastic, glass . . . supply or return . . . compatible with all basic ceiling systems.

Units can be used individually or in combination with lighting fixtures equipped with matching enclosing elements.



BARBER-COLMAN COMPANY
ROCKFORD, ILLINOIS

DAY-BRITE LIGHTING, INC.
ST. LOUIS, MO., SANTA CLARA, CAL.

TWO GREAT NAMES IN ENGINEERED LIGHTING AND AIR DISTRIBUTION.

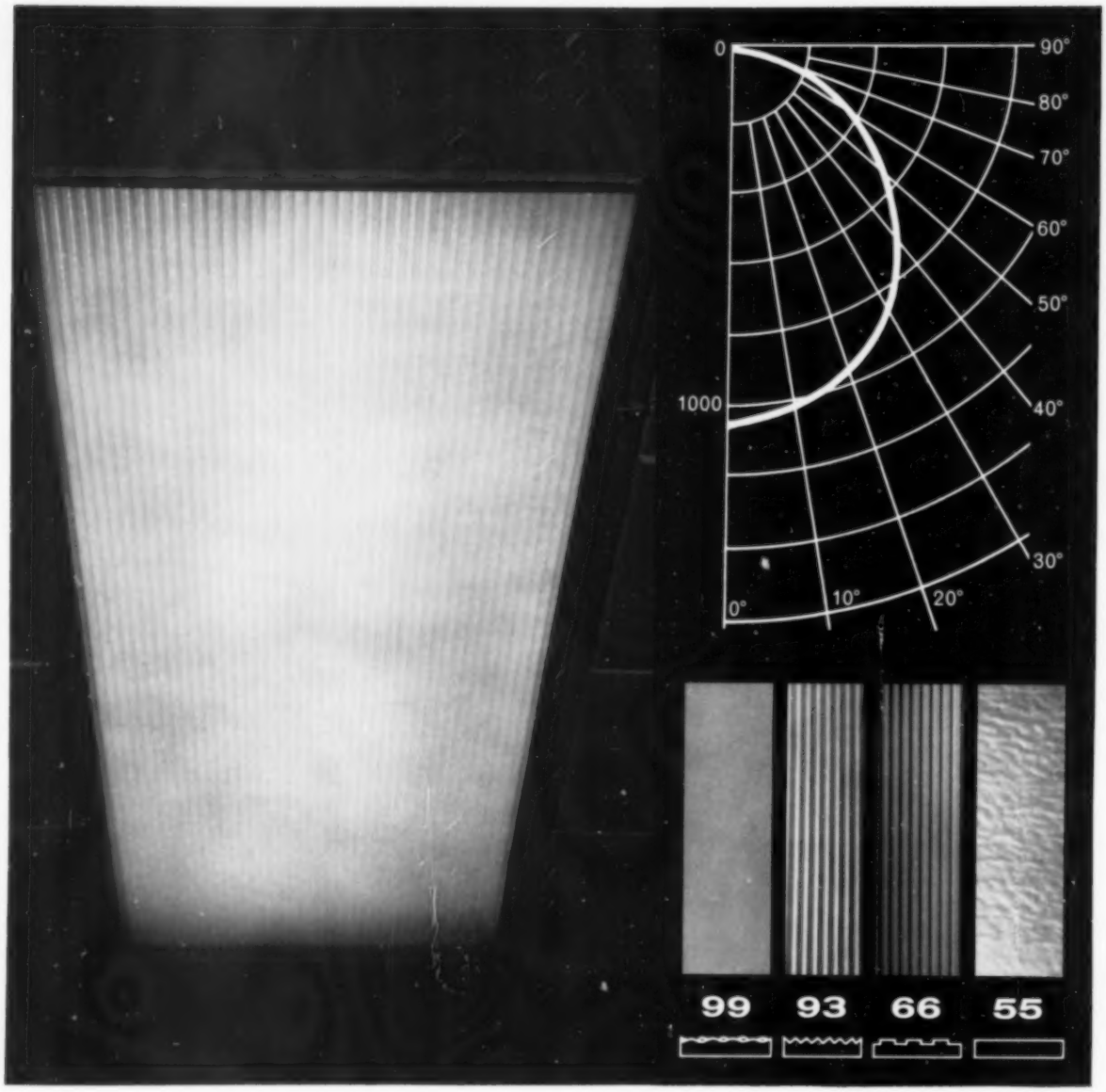
. . WITH LIGHT AND AIR

PATENTED DOUBLE WALL CONSTRUCTION

Air passes through separate chamber completely isolated from fluorescent lamps. Stabilized light output . . . Unequalled in-service performance . . . No reduction in luminous area.

For complete selection and application data, write today for your copy of the new 24-page book "Comfort Conditioning with Light and Air". Day-Brite Lighting, Inc., 6260 N. Broadway, St. Louis 15, Mo. or Barber-Colman Co., Dept. B, 1101 Rock Street, Rockford, Illinois.

*Patent No. 2564334, other patents pending.



4 Alba-Lite® patterns give soft, pleasant diffusion

If your customers need soft, diffused lighting, specify Corning ALBA-LITE panels.

The four patterns provide either the strong, horizontal accents of ribs and fluting (patterns 66 and 93) or the indeterminate wave and pebble effects of patterns 55 and 99.

Alba-Lite is a light, solid opal glass available in rolled sheet form, flat. Light diffusion is secured through the special composition of the glass rather than by any surface treatment. Because it is not color-selective, it transmits the true color of any light source. Being opal in composition, it blends colors and permits various color temperature lamps to be used in a single fixture.

Being *glass*, it won't warp, sag, bend. It can't discolor; cleans with a wipe.

Recommended applications for Alba-Lite include areas where glare must be minimized, as in drafting rooms and inspection areas. In reception rooms and sales areas where soft goods are displayed.

For complete data on Alba-Lite performance and design, write Lighting Sales Department, 61 Crystal St., Corning, N.Y.

CORNING GLASS WORKS

CORNING MEANS RESEARCH IN GLASS

COMMITTEE PERSONNEL

COMMITTEES 1959-1960

All committees are appointed by the President, subject to approval of the Council. Except as provided in the Constitution, appointments terminate at the time of the first Council meeting of the following administration. The scope of each committee is indicated.

J. B. Browder, President, ex-officio member of all Standing, General and Task Committees, except Board of Fellows, Board of Nomination and Medal Award Committee.

R. G. Slauer, Vice-President, ex-officio member of all Technical Committees, (by appointment).

STANDING COMMITTEES

COUNCIL EXECUTIVE—To conduct the affairs of the Society between Council meetings.

J. B. Browder, Chairman, Georgia Power Co., 75 Marietta St., N.W., Atlanta, Ga.

J. R. Chambers — W. P. Lowell, Jr.
G. F. Dean — R. G. Slauer

BOARD OF FELLOWS—To evaluate the eligibility of candidates for transfer to the grade of Fellow, according to procedures approved by Council.

Willard Allphin, Chairman, Sylvania Electric Products, Inc., Salem, Mass.

L. E. Barbrow — Leland H. Brown
J. W. Bateman — Bruce J. Jensen
George P. Wakefield

FINANCE—To have direct supervision of the financial affairs of the Society and to present to the Council an annual report on its financial condition. To make recommendations to the Council as to the investment of moneys and upon all specific appropriations. To prepare and submit for approval of Council not later than the first new Council meeting a budget of income and expense for the ensuing fiscal year.

A. C. Barr, Chairman, General Electric Co., Nela Park, Cleveland, Ohio.
W. P. Lowell, Jr., Treasurer, ex-officio, Sylvania Electric Products, Inc., 60 Boston St., Salem, Mass.

H. S. Beagle — C. C. Shotwell
Max D. Orr — R. M. Zabel

GENERAL BOARD OF EXAMINERS—To investigate the qualifications of all applicants for admission to membership; to elect or reject applicants for the grade of Associate Member and Student Member, to report such action to the Council; and to make recommendations to the Council regarding applications for transfer or election to the grade of Member or Retired Member, and for transfer to the grade of Member Emeritus.

H. E. D'Andrade, Chairman, General Electric Co., 570 Lexington Ave., New York, N. Y.

Svend W. Bruun — Taylor Barr

PAPERS—To procure, review and approve all technical papers and discussions thereof, for presentation before National Conferences of the Society.

Floyd W. Sell, Chairman, The Detroit Edison Co., 2000 Second Ave., Detroit, Mich.

B. S. Benson, Vice-Chairman, Benjamin Electric Mfg. Co., Des Plaines, Ill.
F. C. Breckenridge — J. William Griffith
James Cox — J. S. Hamel
C. M. Cutler — Leon T. Johnson
H. F. Davidson — T. C. Sargent
Kurt Franck — G. A. Trosper
O. B. Goldsmith — George Wakefield
R. S. Wiseman

PUBLICATIONS—To be responsible for the procurement, review and approval of all material for the publications of the Society other than technical papers approved by the Papers Committee for presentation at National Conferences of the Society and their discussions and committee reports, for which it will have publication responsibility only. Shall also be responsible for the editing, printing and business management of the publications of the Society; specific exceptions may be made by Council.

R. M. Zabel, Chairman, Westinghouse Electric Corp., Bloomfield, N. J.

R. W. Morris, Vice-Chairman, General Electric Co., Nela Park, Cleveland 12, Ohio

C. L. Amick — George Clark
Brooks Chassaing — Floyd W. Sell
Nelson Warner

Technical Data Sheets

C. L. Amick, Chairman, Day-Brite Lighting Inc., 5411 Bulwer Ave., St. Louis, Mo.
Berlon C. Cooper — Vernon T. Kempf
Leon T. Johnson — Anthony J. Koechel

Residential Data Sheets

Elizabeth A. Meehan, Chairman, Philadelphia Electric Co., 211 S. Broad St., Philadelphia, Pa.

GENERAL COMMITTEES

ADVANCE PLANNING—To study the long range objectives of the Society—its operation, program, publication activities, membership classifications and financial structure, and to make recommendations to Council.

J. Dixon Mitchell, Chairman, Westinghouse Electric Corp., 2260 Peachtree Industrial Blvd., Chamblee, Ga.

A. C. Barr — John J. Neidhart
C. W. McCormick — L. C. Twichell
W. P. Lowell, Jr. — J. D. Whitnell

ALLIED ARTS—To encourage and assist local competitions in allied arts, in cooperation with technical committees and interested local groups.

J. D. Whitnell, Chairman, Arizona Public Service Co., P.O. Box 2591, Phoenix, Ariz.

Karl A. Staley, Secretary, General Electric Co., Nela Park, Cleveland 12, Ohio

Carl Albach — L. T. Kight
Roy Dahlin — William M.C. Lam
John Felton — Edward Rambusch
John A. Russell

APPLIED LIGHTING COMPETITION—To encourage and assist local and regional competitions and to conduct the national competition during the National Technical Conference, in accordance with procedures approved by the Council.

J. C. Wilson, Chairman, J. A. Wilson Lighting & Display, Ltd., 280 Lakeshore Road, Toronto, Ont.

J. M. Chorlton — Harry Nellis
G. F. Dean — Joseph Thomas

BOARD OF NOMINATION—To prepare a nomination ticket containing the names of those who are deemed best suited to serve as officers and directors in positions to be filled at the ensuing election.

M. N. Waterman, Chairman, Westinghouse Electric Corp., Bloomfield, N. J.

K. M. Reid — G. J. Taylor
and Regional Representatives

CONSTITUTION AND PROCEDURES—To prepare proposed amendments to the Constitution and By-laws, to prepare statements of policies and procedures consistent with the Constitution and By-laws, and to report to Council.

L. C. Twichell, Chairman, Rochester Gas & Electric Corp., 89 East Ave., Rochester 4, N. Y.

G. F. Dean — C. C. Keller
R. F. Hartenstein — Glenn E. Park
Walter Sturrock

DEFENSE COORDINATING—To contact various government agencies concerned with national security suggesting cooperation and participation in specific projects as an aid to solution of their problems. Recommending the placement of lighting study projects in present committees or the appointment of study project committees to the Society President and to expedite such study projects and guide accepted reports into proper Government channels.

J. W. Bateman, Co-Chairman, Canadian General Electric Co., Ltd., 212 King St. W., Toronto, Ont.

A. F. Wakefield, Co-Chairman, The Wakefield Co., Vermilion, Ohio.

H. R. Blackwell — O. P. Cleaver
R. B. Brown, Jr. — John S. Walsh

HISTORICAL—To assemble and make available for current reference and to prepare in suitable and durable form for posterity, such historical facts, printed memorabilia, photographs, voice records, museum specimens and allied items as may be judged worthy of composing a continuing digest of the record of the Society's history.

H. L. Logan, Chairman, Holophane Co., Inc., 342 Madison Ave., New York 17, N. Y.

W. F. Bear — Leo Dolkart
James Cravath — C. A. B. Halvorson
Julius Daniels — S. G. Hibben
J. L. Stair

MEDAL AWARD—To evaluate the eligibility of candidates for award of the I.E.S. Medal according to procedures approved by the Council.

J. F. Whitehead, Jr. Chairman, Day-Brite Lighting, Inc., 5411 Bulwer Ave., St. Louis 7, Mo.

Milton B. Hastings — Edward Rambusch
W. F. Little — G. J. Taylor
H. H. Magdsick — A. F. Wakefield
Kirk M. Reid — M. N. Waterman

MEMBERSHIP—To develop plans and supervise the operation of the individual membership activity of the Society.

J. C. Forbes, Chairman, General Electric Co., Nela Park, Cleveland 12, Ohio

A. C. Brodeur — H. J Poehling
R. M. Taylor
and Regional Representatives

(*Continued on page* 38A)

(*Continued from page 37A*)

NATIONAL TECHNICAL CONFERENCE—To be completely responsible, subject to the approval of Council, for the general coordination of all conference activities, for selecting and recommending time and place, for review of the plans and budgets of the National Technical Conference Executive Committee, and in cooperation with the Papers Committee for the satisfactory time allocation for the Technical Papers sessions, according to Procedures and Policies as adopted by Council.

C. L. Amick, Chairman, Day-Brite Lighting, Inc., 5411 Bulwer Ave., St. Louis, Mo.

J. Carl Wilson, Vice-Chairman, J. A. Wilson Lighting & Display, Ltd., 280 Lakeshore Rd., Toronto, Ont.

A. C. Barr	C. W. McCormick
J. W. Bateman	C. D. Miller
R. W. Brown	J. D. Mitchell
Brooks Chassaing	P. M. Rutherford
John B. Deck, Jr.	Floyd W. Sell
R. T. Dorsey	L. E. Tayler
C. N. Laupp	N. C. Warner

1960 Conference Executive Committee

Nelson Warner, Chairman, Westinghouse Electric Corp., 306 Fourth Ave., Pittsburgh, Pa.

H. R. Jones, Vice-Chairman, West Penn Power Co., Cabin Hill, Greensburg, Pa.

C. D. Miller, Vice-Chairman, Duquesne Light Co., 435 Sixth Ave., Pittsburgh, Pa.

J. P. Boyden	J. A. Hodges
Mrs. J. P. Boyden	D. W. Loucks
H. Briggs, Jr.	R. G. MacDonald
O. C. Brinkerhoff	G. H. Maize
C. A. Conklin	F. J. Powers
C. M. Crysler	G. W. Provost
M. Duckworth	D. C. Thomas

PUBLIC RELATIONS AND INFORMATION—To prepare and disseminate information about the activities, accomplishments, programs, objectives and policies of the Society and about the place of illuminating engineering in modern society; to formulate and submit public relations policies and plans to the Society.

W. A. Dalrymple, Chairman, Amalgamated Electric Corp., Ltd., 384 Pape Ave., Toronto, Ont.

R. E. Ballard, Vice-Chairman, Connecticut Power & Light Co., P.O. Box 2010, Hartford, Conn.

John F. Eichorn	R. W. Sclater
John Ronayne	L. E. Tayler

Gordon Wells

REGIONAL ACTIVITIES—To represent the respective Regions before the Council and to keep the Council informed regarding the affairs of the Regions. To stimulate Society activities, to encourage joint meetings of Sections and Chapters including Regional Conferences within the respective Regions, and to promote the expansion of the Society.

J. R. Chambers, Chairman, Appleton Electric Co., 1701-1759 Wellington Ave., Chicago, Ill.

J. E. Barnes	J. B. Deck, Jr.
R. W. Brown	J. M. Gensburger
Cecil L. Cannon	C. D. Miller
Brooks Chassaing	L. S. Reed
J. M. Chorlton	R. L. Smart

B. A. Travis

RESIDENCE LIGHTING FORUMS—To stimulate and assist the Residence Lighting Forums of the Society and to encourage the formation of additional forums. To conduct a Residence Lighting Forum in connection with the National Technical Conference.

Eve Freyer, Chairman, Westinghouse Electric Corp., Bloomfield, N. J.

Katherine Goodall	Aileen Page
Ben Goodman	R. M. Taylor
Emma A. Koch	Virginia Skinner

and Chairmen of the local Forums

SUSTAINING MEMBERSHIP—To develop plans and supervise the operation of the Sustaining Membership activity in the Society according to the Procedures and Policies adopted by Council.

G. J. Taylor, Chairman, Day-Brite Lighting, Inc., 212 South Central Ave., Clayton, Mo.

B. F. Benning	E. C. Huerkamp
Warren W. Booth	J. J. McLaughlin
Eric H. Church	R. L. Sawyier
G. J. Gillen	C. C. Shotwell

TELLERS, COMMITTEE OF—To count the votes in the national election ballot and prepare a report for presentation to Council.

M. E. Welch, Chairman, Rambusch Decorating Co., 40 W. 13th St., New York, N. Y.

Arthur H. Brooke	Walter S. Greenwood
Ralph E. Crockett	Robert A. Langer

TRUSTEES, I.E.S. HEADQUARTERS RETIREMENT PENSION PLAN

K. M. Reid, Chairman, General Electric Co., Nela Park, Cleveland 12, Ohio

W. P. Lowell, Jr. G. J. Taylor

TASK COMMITTEES

IES TERRITORIAL AND ORGANIZATIONAL TASK COMMITTEE—To study regional boundaries with respect to the preparation of a plan to encompass the future growth pattern of the Society.

J. R. Chambers, Chairman, Appleton Electric Co., 1701-1759 Wellington Ave., Chicago 13, Ill.

Brooks Chassaing	C. D. Miller
J. M. Chorlton	J. D. Mitchell
G. F. Dean	M. N. Waterman

J. D. Whitnell

PRESIDENT'S TASK COMMITTEE—To secure special gifts in the United Engineering Center campaign.

J. B. Browder, Chairman, The Georgia Power Co., 75 Marietta St., Atlanta, Ga.

H. A. Anderson	L. E. Johnson
J. W. Bigley	C. C. Keller
W. P. Carpenter	J. J. McLaughlin
Brooks Chassaing	R. A. Palmer
Julius Daniels	L. S. Reed
J. F. Finn	K. M. Reid
J. M. Gensburger	P. M. Rutherford
J. S. Hamel	C. C. Shotwell
A. R. Hampsey, Jr.	Joseph Thomas
M. B. Hastings	Beverly Travis
J. H. Hull	L. C. Twichell
I. L. Illing	J. S. Walsh

RESEARCH FINANCING—To determine how the long range financial needs of the Illuminating Engineering Research Institute research program may be met.

Kirk M. Reid, Chairman, General Electric Co., Nela Park, Cleveland, Ohio.

C. C. Shotwell	A. F. Wakefield
R. G. Slauer	M. N. Waterman
E. M. Strong	J. F. Whitehead, Jr.

TASK COMMITTEE TO STUDY LIGHTING SERVICE COMMITTEE—To study future scope and program of the Lighting Service Committee, and to report to Council.

W. P. Graham, Chairman, Philadelphia Electric Co., 211 S. Broad St., Philadelphia, Pa.

G. J. Gillen	George J. Kennedy
Bruce J. Jensen	M. N. Waterman

TECHNICAL COMMITTEES

AVIATION AND SIGNAL—To study the application of light and lighting to the spaces and functions involved in the operation of aircraft.

M. A. Warskow,* Chairman, Airborne Instrument Laboratories, Inc., Melville, Labs., Walt Whitman Rd., Melville N. Y.

F. C. Breckenridge,* Technical Secretary, National Bureau of Standards, Washington 25, D. C.

Aircraft Lighting

Warren Hulke,* Chairman, Soderberg Manufacturing Co., 628 S. Palm Ave., Alhambra, Calif.

W. E. Woodson, Secretary, Convair Corp., Division of General Dynamics, P.O. Box 1950, San Diego, Calif.

W. C. Fisher, Papers Coordinator, Bureau of Aeronautics, Dept. of Navy, Washington 25, D. C.

F. C. Ashe	J. Gordon Hoffman
E. Boghosian	W. D. Howell
F. B. Brady	J. P. Hoxie
F. C. Breckenridge	W. A. Jensen
D. I. Coggins	D. C. Miller
H. A. Cramer	M. A. Mortensen
R. K. Davis	T. H. Projector
C. A. Douglas	Norbert Schwenkler
I. Fagin	F. C. Shipley
S. R. Goldfarb	R. J. Stefany
P. H. Greenlee	R. A. Stone
G. K. C. Hardesty	M. A. Warskow

Bibliography

F. C. Ashe, Chairman, Kopp Glass Inc., Palmer St., Swissvale, Pittsburgh 18, Pa.

Cockpit Lighting

Dean Pierce, Chairman, Lockheed Aircraft Corp., Burbank, Calif.

Al Bennett	J. Ransford

Charles Touhy

Exterior Lighting

M. L. Clayton, Chairman, Convair, a Division of General Dynamics Corp., P. O. Box 1950, San Diego, Calif.

Paul Greenlee	Jack Shearer
E. A. Jensen	Wm. Struklj

Interior Lighting

Wesley Woodson, Chairman, Convair, a Division of General Dynamics Corp., P. O. Box 1950, San Diego, Calif.

R. K. Davis	Carl F. Jensen
W. Fisher	A. L. McIntyre
Edwin Ford	C. S. Millikan
Robert Hadzor	C. T. White

Lamps (Small)

M. A. Mortensen, General Electric Co., Nela Park, Cleveland 12, Ohio.

E. Bosworth	W. T. Harding
C. Christenson	W. Lawton
W. Fisher	R. Stone

H. R. Van Saun

Ground Lighting

R. J. Stefany,* Chairman, Westinghouse Electric Corp., 1625 K St., N.W., Washington 6, D. C.

J. P. Hoxie, Secretary, Corning Glass Works, Corning, N. Y.

C. A. Douglas, Papers Coordinator, National Bureau of Standards, Washington 25, D. C.

J. F. Angier	L. W. Hornfeck
F. C. Ashe	Warren Hulke
E. Boghosian	W. A. Jensen
F. B. Brady	G. F. Johnston
F. C. Breckenridge	C. E. Leberknight
W. D. Callaghan	C. J. McDonald
F. E. Carlson	W. A. Pennow
P. B. Clark	F. C. Shipley
G. K. Clement	L. C. Simpson
D. I. Coggins	R. A. Stone
V. E. Converso	L. C. Vipond
E. A. Cuttrell	A. E. Wallis
O. F. Farris	M. A. Warskow
D. M. Finch	H. A. Williams
J. S. Haney	J. P. Wilson
R. D. Hartz	A. B. Winters

*Members of Executive Committee.

Approach Lighting

D. I. Coggins, Chairman, Sylvania Electric Products Inc., Photoflash Division, 60 Boston St., Salem, Mass.

E. A. Cuttrell	O. F. Farris
C. A. Douglas	G. M. Kevern

Aviation Lamps (Large)

F. E. Carlson, Chairman, General Electric Co., Nela Park, Cleveland 12, Ohio.

(*Continued on page 42A*)

PLAN NOW—ONE SYSTEM FOR TEN SERVICES!

Centron-10

Within one centralized system [illegible] by Sunbeam Lighting Company, incorporates up to ten hospital bedroom services normally installed separately. New standards of convenience both to patients and hospital personnel can also be achieved

fully enclosed general lighting component

handsome easy-to-clean Alumalite finish

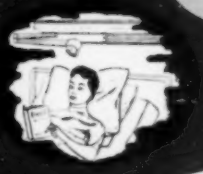
TV and radio antenna leads

provisions for nurse call systems such as Executone

dual telephone receptacle

reading lamp on swivel

retractable heavy duty lamp supports



examination lamp

provisions for oxygen & vacuum systems such as N.C.G.

convenience outlets

No longer is it necessary to plaster walls with cramped service outlets. Now, in one compact, sleekly styled "package" for each room, Centron-10 system provides home-like general lighting —moveable, shielded reading lamp – high intensity, color-corrected examination lamp – provisions for [illegible] nurse call systems – provisions for oxygen and vacuum systems – [illegible] night light – phone outlets – convenience outlets – TV leads-in – and a swivel arm for intravenous apparatus.

THERE IS NO OTHER SYSTEM LIKE IT!

Write today for [illegible] showing how you can save up to $32.50 per bed in installation costs by planning and including the Centron-10 system.

Centron-10

SUNBEAM LIGHTING COMPANY

777 East 14th Pl., Los Angeles, Calif. – 3840 Georgia St., Gary, Ind.

but only the Westinghouse Lamp has six

Despite similar appearance and ratings, these fluorescent lamps are *not* the same. One is a better lamp—and a better buy—because it's the only fluorescent lamp with all 6 advances described below. That lamp is made by Westinghouse. It costs you no more than any other leading brand—but it will give you years of trouble-free, efficient lighting.

1. **MORE EFFICIENT PHOSPHORS**—A special Westinghouse process selects Ultralume™ phosphor particles of a size proven to give more efficient lighting.

2. **BRIGHTER END TO END**—Lead wires are plated with super-hard Chrome Vanadium to make sure Westinghouse tubes *stay* bright, end to end.

3. **BUILT-IN "SHOCK ABSORBERS"**—Specially designed Westinghouse anodes act as buffers to cushion the terrific shock of electron bombardment and improve lamp life.

4. **"RAINCOATS" FOR RELIABLE STARTING**—Silicone "raincoats"

important advances that make it a better buy!

disperse moisture which can collect on exterior surfaces and prevent lamps from starting.

5. MIXED GASES—Westinghouse uses a precise mixture of certain rare gases, under exact pressure, to improve the light output.

6. TRIPLE-COILED ELECTRODES—To protect electrodes from the sudden electron bombardment when the lamp is first turned on. Emission material is quickly heated, fully protected.

Regardless of the type or wattage of fluorescent lamps you buy, you will get better value, more light for your money, and longer, trouble-free service if you specify and insist on Westinghouse fluorescent lamps. Westinghouse makes a complete line, from tiny 4-watt lamps for instrument lighting to the giant 96-inch Super-Hi™ Lamps for store, street, and factory lighting. Contact your authorized Westinghouse lamp agent or nearest Westinghouse sales office.

YOU CAN BE SURE... IF IT'S Westinghouse

WESTINGHOUSE LAMP DIVISION, Westinghouse Electric Corporation, Bloomfield, N. J.

(Continued from page 38A)

BIBLIOGRAPHY

F. C. Ashe, Chairman, Kopp Glass Inc., Palmer St., Swissvale, Pittsburgh 18, Pa.

J. P. Hoxie

HELIPORT LIGHTING

V. E. Converso, Chairman, Port of New York Authority, 111 Eighth Ave., New York, N. Y.

J. S. Haney — H. Higgins
R. D. Hartz — E. G. Rudberg
L. C. Vipond

RUNWAY LIGHTING

A. E. Wallis, Chairman, Wright Air Development Center, Wright Patterson Air Force Base, Dayton, Ohio.

L. Achitoff — W. A. Jensen
G. K. Clement — C. J. McDonald
C. A. Douglas — R. L. Paugh
R. C. Herner — L. C. Vipond

SEADROME LIGHTING

R. D. Harts, Chairman, Bureau of Aeronautics, Navy Department, Washington, D. C.
R. C. Preston — J. E. Wesler

SERVICE AREA LIGHTING

E. B. Karns, Chairman, Westinghouse Electric Corp., 1216 W. 58th St., Cleveland 1, Ohio.

R. H. Goodman — G. F. Johnston
W. A. Jensen — H. A. VanDusen, Jr.
H. W. Wenson

TAXIWAY LIGHTING

H. B. Decker, Chairman, Federal Aviation Agency, Columbian Bldg., 416 - 5th St. N. W., Washington, D. C.

G. K. Clement — R. L. Paugh
V. E. Converso — R. Pierce
J. F. Davis — E. G. Rudberg
J. D. McKinney — H. A. Williams

Signal Lighting

J. F. Angier,* Chairman, 14 Valley View Ave., Washington 12, D. C.

F. C. Breckenridge — C. A. Douglas
W. E. K. Middleton

COLOR — To study, evaluate and report on the effect of color in relation to the art and science of illumination.

R. C. Allison, Chairman, Engineering and Design Dept., The T. Eaton Co., Ltd., 190 Yonge St., Toronto 1, Ont.

W. E. Carswell — G. F. Dean

DAYLIGHTING — To study the problems involved in daylighting, develop recommended practices and report thereon.

J. W. Griffith, Chairman, Southern Methodist University, Industrial Engineering Dept., Dallas, Texas.

W. J. Arner — R. C. Kendall
R. L. Biesele, Jr. — H. F. Kingsbury
R. A. Boyd — E. M. Linforth
A. A. Brainerd — R. W. McKinley
H. S. Bull — F. W. Mowrey
T. Carson — Philip O'Brien
Benj. H. Evans — F. K. Sampson
W. B. Ewing — Paul W. Seagers
C. D. Gibson — D. E. Spencer
B. F. Greene — K. C. Welch
J. J. Kemendo — O. F. Wenzler**
C. J. Youngblood

**Alternate for W. J. Arner.

Revision of Recommended Practice for Daylighting

R. W. McKinley, Chairman, Pittsburgh Plate Glass Co., 1 Gateway Center, Pittsburgh 22, Pa.

W. J. Arner — R. C. Kendall
E. W. Conover — H. F. Kingsbury
W. B. Ewing — E. M. Linforth
B. F. Greene — T. H. MacDonald
R. M. Hanes — F. W. Mowrey
J. S. Herbert — C. J. Youngblood

DESIGN PRACTICE — To study published data on coefficients of utilization, room indexes, maintenance coefficients and other elements entering into calculations for lighting design; develop standard methods for use in Society publications and report thereon.

R. S. Wiseman, Chairman, Research & Photometric Section, U. S. Army Engineer Research and Development Laboratories, Fort Belvoir, Va.

G. W. Clark — Phelps Meaker
Ward Harrison — J. J. Neidhart
Harry W. Horn — H. A. Odle
E. H. Salter

EDUCATION — To study and encourage lighting education and training for professional careers in schools, colleges and elsewhere; to prepare educational and training material on fundamental and advanced concepts of light and illumination, and to further its adoption in courses conducted by Sections and Chapters.

Alston Rodgers, Chairman, General Electric Co., Nela Park, Cleveland 12, Ohio.

O. P. Cleaver — H. W. Horn
E. L. Fairchild — Roy A. Palmer
D. M. Finch — R. C. Putnam
W. A. Hedrich — T. H. Shepherd
P. H. Hildebrand — R. S. Wiseman
I. A. Yost

Revision of I.E.S. Courses

C. W. Zersen, Coordinator, Chicago Lighting Institute, 140 S. Dearborn St., Chicago, Ill.

Preparation of Brochure on "Opportunities in Illuminating Engineering"

J. L. Tugman, Chairman, General Electric Co., Nela Park, Cleveland 12, Ohio.

Revision of "Lighting Fundamentals" Course

R. E. Wozniak, Chairman, Chicago Lighting Institute, 140 S. Dearborn St., Chicago, Ill.

Robert Allen — B. F. Avery
A. M. Bacalar

Revision of "Advanced Lighting Design Problems" Course

R. R. Lusk, Chairman, Commonwealth Edison Co., 7601 S. Lawndale Ave., Chicago 29, Ill.

Gerald Marks — J. F. Parsons
William Weibel

Science Textbook Review—To work with the Better Light Better Sight Bureau in providing an authoritative review service to assist authors and editors preparing new textbooks or revising existing ones, to insure that text and illustrations on light and lighting are technically correct and up-to-date. The BLBS Bureau will contact the publishers of science textbooks for use in elementary and secondary schools, obtain the material to be reviewed and act as liaison with this subcommittee, who will do the actual work of review and comment.

J. L. Tugman, Chairman, General Electric Co., Nela Park, Cleveland 12, Ohio.

E. L. Fairchild — P. H. Hildebrand
W. A. Hedrich — J. F. Parsons

HANDBOOK—To have continuous responsibility for appraising the service rendered by the Handbook, for its accuracy and improvement; to advise Council when revisions and new editions are needed. To revise and arrange the technical content of the Handbook; to lay out, plan, and arrange for development of individual sections primarily through appropriate technical committees, to consult with the Publications Committee on its presentation of a suitable publication budget for Council approval; to be responsible to Council for the format, accuracy, and treatment of material.

M. N. Waterman, Chairman, Westinghouse Electric Corp., Bloomfield, N. J.

B. J. Jensen — J. J. Neidhart

INDUSTRIAL — To initiate, follow up and coordinate lighting study projects in the industrial field, review the reports of the various subcommittees in this field and make recommendations to Council.

L. G. Parks, Chairman, Ebasco Services, Inc., 2 Rector St., New York, N. Y.

Theodore Ake — W. H. Kahler
A. A. Brainerd — Norman T. Kridel
M. M. Buzan — E. A. Linsday
H. A. Cook — Howard Long
R. E. Harz — D. J. O'Neill

Aircraft Manufacturing

J. G. Felton, Jr., Chairman, Sylvania Electric Products, Inc., 100 Fordyce St., Dallas, Texas.

Robert S. Clubley

Clothing

Norman T. Kridel, Chairman, Rochester Gas & Electric Co., 89 East Ave., Rochester, N. Y.

Electronics Industry

R. S. Clubley, Chairman, General Electric Co., Large Lamp Dept., 2747 South Malt Ave., Los Angeles 22, Calif.

Graphic Arts

Ralph Enghouser, Chairman, Sylvania Electric Products Inc., 4700 Parkside Ave., Philadelphia, Pa.

Outdoor Production Areas

H. A. Cook, Chairman, Detroit Edison Co., 2000 Second Ave., Detroit 26, Mich.

Donald R. Brown — D. J. O'Neill
William Coffey — W. R. Preece, Jr.
R. E. Faucett — G. L. Sealy
E. I. Feak — Fred Snider
Theodore Summers

Recommended Practice

D. J. O'Neill, Chairman, Holophane Co., Inc., 342 Madison Ave., New York, N. Y.

Theodore Ake — Paul E. King
M. B. Bunson — E. A. Linsday
W. H. Kahler — W. S. Till
H. W. Wenson

Sawmills

James Barnes, Chairman, Pacific Gas & Electric Co., P. O. Box 540, San Rafael, Calif.

INSTITUTIONS — To initiate, follow up and coordinate lighting study projects in the field of public buildings and private institutions, review the reports of the various study subcommittees in this field and make recommendations to Council.

R. D. Bradley, Chairman, Day-Brite Lighting, Inc., 5411 Bulwer Ave., St. Louis, Mo.

B. F. Avery — C. N. Laupp
L. V. James — J. H. McCulloch

Churches

George Shoemaker, Chairman, Philadelphia Electric Co., 211 S. Broad St., Philadelphia 5, Pa.

John Adams — T. Norman Mansell
Anthony L. Bleecker — A. C. Sangster
Henrik W. Olsen

Dining Areas

George Gilleard, Chairman, Curtis Lighting Inc., 6135 W. 65th St., Chicago 38, Ill.

(Continued on page 44A)

A Superior Sealing Gasket and Jointing Material...

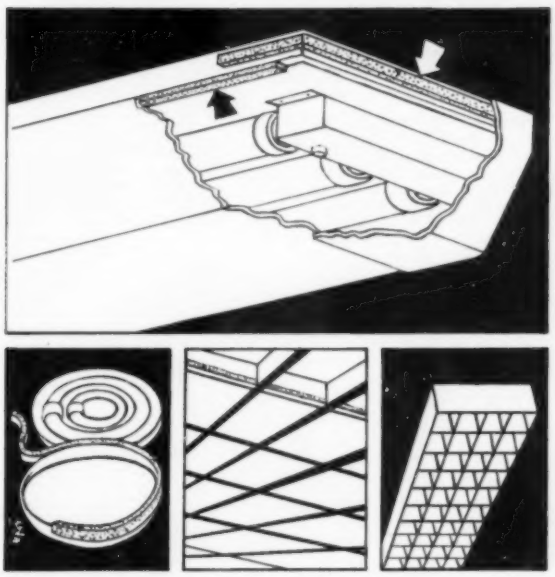
New Tesamoll FOAMSTIK® Tape offers many advantages over felt, foam rubber, and other materials as a cushioning and insulating medium in the assembly and installation of fluorescent and incandescent lighting fixtures and systems of every type — interior and exterior... industrial, commercial, residential.

Tesamoll

URETHANE PLASTIC SELF-ADHESIVE

FOAMSTIK® TAPE

GUARANTEES PERMANENT TIGHT SEAL-CUSHIONS HARMFUL VIBRATIONS



FOAMSTIK® provides resilient cushioning and good insulation between glass and frame of lighting fixtures and wherever desirable to seal out air, moisture, dust particles, insects. It helps keep mountings flush, secure to ceiling or wall. It protects against vibration and shock. Prevents loosening, slipping, rattling, swinging. Saves damage to parts, mechanisms, attachments such as brackets, latches, lamp holders, etc. Improves installation of luminaires, troffers, strip ceiling mounts, diffusers, reflectors, color filters.

EASY TO USE!

Sticks fast instantly • Stays on permanently.

Just peel off protective liner and press FOAMSTICK® on any smooth, firm surface — metal, glass, plastics, fiberglas, wood. **Sticks on contact.** No moistening. No glue. No mess. Cut lengths with snip scissors. No waste. Saves time. Reduces costs.

Get first-hand proof in a hurry! Mail Coupon for FREE Samples

If you are a lighting equipment manufacturer, electrical contractor, wholesaler-distributor, or installer, you are cordially invited to send for FREE Samples of Tesamoll FOAMSTICK® Tape for testing so you can see how it improves performance and saves money. Right now!

Tesamoll FOAMSTIK® Tape is a highly flexible, extremely light weight pressure-sensitive tape of urethane plastic foam material. Backed by a special, powerful adhesive masked by an easily-peeled-off grained poly-vinyl-chloride liner. Excellent compressability and low compression set. High thermal insulation value. Tough. Tensile strength, 22-30 lbs./in. of width. Weight, 1/3rd of foam rubber. Chemically stable. Unaffected by most chemicals and fumes, light, water, oils, temperature extremes.
Impervious to attack by rot, rust, mildew, insects.

Available in convenient rolls, easy to handle or store.

Thicknesses: ⅛", ¼", ½". Widths: ¼" to 18½". Can be die cut

Standard Colors: Black, White and Grey.

UNITED MINERAL & CHEMICAL CORP. U. S. Agents
16 Hudson Street, New York 13, N. Y. BEekman 3-8870

UNITED MINERAL & CHEMICAL CORP.
16 Hudson Street, New York 13, N.Y. Dept. IE4

Send me FREE SAMPLES and full information on TESAMOLL FOAMSTIK Tape right away!

Name ..... Title .....

Address .....

Firm .....

City ..... Zone ..... State .....

(*Continued from page* 42A)

Hospitals

N. L. Griffin, Chairman, Dept. of Health, Education & Welfare, Public Health Service, Div. of Hospital & Medical Facilities, Washington 25, D. C.

H. W. Alexander	H. L. Logan
L. J. Buttolph	R. C. Putnam
E. H. Greppin	Paul Seagers
H. M. Sharp	

JOINT FARM (IES-American Society of Agricultural Engineers)—To study the application of light and lighting of farm buildings, surrounding work areas and other rural locations and to report thereon.

Morris Lloyd, Chairman, Niagara Mohawk Power Corp., Buffalo 3, N. Y.

Ervin Baker	J. P. Schaenzer
J. P. Ditchman	M. O. Withed
D. E. Wiant	

JOINT LIGHTING AND AIR CONDITIONING (IES-American Society of Heating, Refrigerating and Air Conditioning Engineers)—To study the relationship between lighting and various factors that enter into the thermal environment and report thereon.

JOINT LIGHTING SURVEY (IES-U. S. Public Health Service)—To outline a method of making a survey of the visual factors of the working environment and the worker's vision and evaluating the findings in terms of visual comfort and effectiveness and eye health.

J. F. Parsons, Chairman, Niagara Mohawk Power Corp., Electric Bldg., Buffalo 3, N. Y.

H. N. Doyle, Vice-Chairman, U. S. Public Health Service, Washington 25, D. C.

Tula Brocard	L. E. Duval, Jr.
L. J. Cahill	A. L. Koven
George Clayton	R. P. Teele

LIGHT CONTROL AND EQUIPMENT DESIGN—Collect and correlate the knowledge and data on means and methods of controlling, directing, reflecting, transmitting and diffusing light and on the principles and practices of equipment design.

J. N. Robertson, Chairman, Los Angeles Dept. of Water and Power, Design and Construction Div., 405 S. Hill St., Los Angeles, Calif.

Milton Buzan, Vice-Chairman, Day-Brite Lighting, Inc., 5411 Bulwer Ave., St. Louis, Mo.

G. R. Baumgartner	R. S. Hawes
W. O. Benjamin	J. J. McLaughlin
W. S. Blitzer	M. E. Robertson
E. H. Church	W. A. Weibel
J. S. Hamel	F. C. Winkler

IES-SPI-NEMA

F. C. Winkler, Chairman, Westinghouse Electric Corp., 1216 W. 58th St., Cleveland 1, Ohio.

George Gilleard	E. H. Salter
George Wakefield	

LIGHT SOURCES — To correlate and report available information as to the physics of light and light production and the characteristics of current light sources.

Herbert A. Anderson, Chairman, Duro-Test Corp., N. Bergen, N. J.

L. E. Barbrow	George Freeman
W. P. Carpenter	D. S. Gustin
R. D. Churchill	Walter Houston
David Cutler	E. F. Kelly
G. E. Davidson	O. Leinhard
R. B. Dull	M. E. Robertson
E. H. Salter	

Color Rendition

Dorothy Nickerson, Chairman, 2039 New Hampshire Ave. N. W., Washington 9. D. C.

C. N. Clark	Norman Macbeth
George Freeman	G. R. Stillwell
C. W. Jerome	Luke Thorington
D. B. Judd	A. W. Weeks
Gunter Wyszecki	

MAINTENANCE — To study the elements contributing to maintenance factors; set up the framework of typical field studies to determine factors; and to stimulate the prosecution of such studies by appropriate agencies.

C. M. Holden, Chairman, Vorlander Lighting, 80 Boylston St., Boston, Mass.

R. D. Bradley	W. C. Fink, Jr.
A. A. Brainerd	Elmo E. Irwin
Francis Clark	Howard Long
Leo Duval	William Lyons
L. M. Endres	F. J. Roche
R. P. Teele	

MERCHANDISING — (formerly Store Committee)—To study the application of light and lighting to the spaces and processes involved in the selling of goods and to report thereon.

W. H. Kahler, Chairman, Westinghouse Electric Corp., 1216 W. 58th St., Cleveland 1, Ohio

Theodore Ake	Norman Falk
R. C. Allison	**Lester Geis**
C. W. Clarkson	Herbert Hoffman
L. H. Dickelman	Richard Kelly
R. T. Dorsey	L. N. Lamboy
Ralph Enghouser	N. J. Sonnenfeld
K. C. Welch	

Service Stations and Parking Areas

E. H. Schaefer, Chairman, Wisconsin Electric Power Co., 231 W. Michigan St., Milwaukee 3, Wis.

James Bale	A. L. Hart
W. G. Barr	M. C. Harsh
D. B. Brown	Frank Lago
H. A. Elwell	G. V. Maddox
J. R. Fairweather	John Mucha
A. B. Winters	

MOTOR VEHICLE (EXTERIOR) — To study the problems of illuminating the night operations of motor vehicles and to make suitable recommendations for promoting maximum safety and convenience including accessory illuminated signal and traffic aids.

R. P. Teele, Chairman, National Bureau of Standards, Washington 25, D. C.

L. L. Beltz	D. M. Finch
H. S. Bull	B. Marsh
W. E. Carpenter	Charles Marsh
L. W. Chubb, Jr.	R. I. Nagel
N. Darmstadter	E. R. Ricker
V. J. Roper	

NOMENCLATURE — To define the terms and standards of illumination, and endeavor to obtain uniformity in nomenclature.

S. K. Guth, Chairman, General Electric Co., Nela Park, Cleveland 12, Ohio.

E. Q. Adams	J. O. Kraehenbuehl
Abraham Abramowitz	W. F. Little
L. E. Barbrow	Philip O'Brien
C. L. Cottrell	Priscilla Fresbrey
D. M. Finch	Harris Reinhardt

OFFICE — To study the lighting requirements of office lighting tasks, develop suitable lighting recommendations and report thereon.

Eric H. Church, Chairman, Lighting Products, Inc., P. O. Box 338 Highland Park, Ill.

W. S. Fisher, Secretary, General Electric Co., Nela Park, Cleveland 12, Ohio.

A. S. Almryde	C. W. McLelland
C. L. Amick	J. J. Neidhart
C. W. Clarkson	G. G. Rae
G. F. Dean	T. H. Shepherd
L. M. Endres	John Sweatte
W. H. Johnson	R. T. Waite
J. L. Kilpatrick	G. P. Wakefield
C. W. Macy	E. H. Witte
R. W. McKinley	R. R. Wylie
J. J. McLaughlin	R. L. Zahour

PROGRESS — To keep in touch with developments in the art of lighting throughout the world and prepare a yearly review of achievements in the art of illuminating engineering for inclusion in ILLUMINATING ENGINEERING.

M. K. Strang, Chairman, Curtis Lighting of Canada, Ltd., 195 Wickstead Ave., Leaside, Toronto 17, Ont.

H. A. Williams, Vice-Chairman, Rohm & Haas Co., Washington Square, Philadelphia, Pa.

Theodore Ake	W. S. Kolb
H. A. Anderson	E. A. Linaday
R. T. Dorsey (alt.)	F. J. Marriett
Norman Falk	**E. C. Pauly**
R. E. Faucett	T. C. Sargent
John Gornet	S. M. Segal
R. E. Harz	R. P. Teele
A. R. Jaeger	R. R. Tipton
Hugh James	R. F. Townsend

PUBLIC CONVEYANCES — Interior Lighting — To study the application of light to all public areas in conveyances used for passenger transportation, including particularly trains, buses, ships, street railways and subways, and report thereon.

QUALITY AND QUANTITY OF ILLUMINATION, Recommendations for — To prepare recommendations of illumination levels, brightness limits and brightness relationships in form applicable to practices.

J. J. Neidhart, Chairman, The Miller Co., Meriden, Conn.

Willard Allphin	W. H. Kahler
R. D. Bradley	**L. G. Parks**
J. M. Chorlton	Thomas J. Seburn
E. H. Church	**E. M. Strong**
J. W. Griffith	**M. A. Warskow**
S. K. Guth	W. W. Weld

RESIDENCE — To study and report on the application of light and lighting in residences; to develop performance recommendations for residence luminaires and to prepare necessary educational aids.

W. F. Little, Chairman, 75 Dalton Rd., Yonkers 2, N. Y.

William Blitzer	Robert J. Murphy
Myrtle Fahsbender	Jan Reynolds
Helen Gibbons	Vito Russo
Benjamin Goodman	Sylvan R. Shemitz
F. J. Marriett	Mary B. Taepke
Elizabeth A. Meehan	H. A. Van Collie
Mary E. Webber	

Revision of "Contemporary Lighting in Modern and Traditional Interiors"

Myrtle Fahsbender, Chairman, Westinghouse Electric Corp., Bloomfield, N. J.

Kaye Leighton	Gladys Miller
Jan Reynolds	

ROADWAY — To establish the scientific principles underlying street and highway lighting; to collect data on the results of the application of such principles to actual practice; to prepare such reports thereon as will assist technicians and benefit the public.

Thomas J. Seburn, Chairman, Bureau of Highway Traffic, Strathcona Hall, Yale University, New Haven, Conn.

L. F. Heckmann, Vice-Chairman, Union Metal Mfg. Co., 143 Maple Ave., N.E., Canton, Ohio.

H. E. Mason, Secretary, City Hall Annex, Room 1032, Philadelphia, Pa.

(*Continued on page* 46A)

KOPP Lighting Glassware, Lenses, Color Filters

Color...light...heat...strength...dimensions...
Engineered to meet your specific needs

Kopp engineering designs lenses, color filters or specialized lighting glassware to meet a wide variety of needs. This includes developing the formula to provide accurate color and the right light transmission and distribution.

It involves the design and production of moulds and establishing controlled manufacturing procedures for custom production. Tempering and other finishing operations assure specialized properties to withstand physical stresses or unusual environmental conditions.

In some cases, Kopp suggests design alterations to give you better performance and lower cost. That's why it pays to contact us early, before your design specifications are finalized. *Ask for bulletin on Kopp Engineered Glass.*

Products illustrated, from the top:

- **Round Flat Fresnel Lens**
- **Aircraft Warning Light Cover**
- **Floodlight Cover Glass**
- **Railroad Roundel**
- **Airport Runway Lens**
- **New 12" Dia. Traffic Signal Lens**
- **Underwater Swimming Pool Lens**
- **Cylindrical Fresnel Lens**

KOPP GLASS

Kopp Glass, INC.

Swissvale, Pennsylvania

(*Continued from page* 44A)

*David M. Baldwin	O. W. Meissner
*James D. Blythe	C. R. Minors
P. C. Box	F. E. Moesta, Jr.
R. P. Brotzman (EEI)	*George Nagel
R. S. Bucher	*J. J. Oberhausen
P. B. Clark	O. P. Ortlieb
W. F. Crosby	*H. W. Osborne
A. R. Dow	*R. J. Palmer
W. H. Edman	*K. L. Partridge
W. B. Elmer	Ellis E. Paul
J. H. Fahey	*Blair E. Plowman
D. M. Finch	C. H. Rex
*H. A. Friede	D. W. Rowten
G. K. Glass	F. J. Schmitt
C. A. B. Halvorson	*L. J. Schrenk
*M. B. Hastings	*Murray D. Segal
W. E. Hawkins	*S. E. Sisco
William Hawley	*J. Homer Shaw
R. M. Hoot	S. M. Starr
G. W. Howie	R. M. Swetland
*Harry Hrivnatz	R. P. Teele
Robert Kaiser	D. A. Toenjes
M. E. Keck	G. A. Trosper
Charles J. Keese	H. F. Wall
G. E. Korten	R. C. Wey
*R. A. Landry	R. M. Williston
*R. B. Marxheimer	Henry Wojcik
H. E. Mason	R. R. Wylie
J. F. McGough	J. W. Young

R. M. Zabel

Parking Area

M. E. Keck, Chairman, Westinghouse Electric Corp., 1216 W. 58th St., Cleveland 1, Ohio.

G. K. Glass	W. E. Schwannhauser
E. H. Schaefer	S. M. Starr

Photographic Studies

W. E. Hawkins, Chairman, Atlantic City Electric Co., 1600 Pacific Ave., Atlantic City, N. J.

A. W. Fowle	F. J. Schmidt
R. M. Hoot	W. E. Schwannhauser

Program and Publicity

W. F. Crosby, Chairman, Corning Glass Works, Corning, N. Y.

*W. B. Hastings	*Robert Kaiser
R. M. Hoot	W. E. Schwannhauser

Research

R. P. Teele, Chairman, National Bureau of Standards, Washington 25, D. C.

W. H. Dorman	B. S. Pritchard
W. B. Elmer	C. H. Rex
D. M. Finch	D. A. Toenjes
M. E. Keck	R. R. Wylie
Charles Keese	Peter Young

R. M. Zabel

Roadway Lighting Principles

C. H. Rex, Chairman, General Electric Co., Outdoor Lighting Dept., Hendersonville, N. C.

P. B. Clark	G. A. Nagel
W. H. Dorman	B. S. Pritchard
W. H. Edman	G. A. Trosper
W. B. Elmer	V. L. Waight
G. W. Howie	H. F. Wall
M. E. Keck	J. W. Young

Standard Practice

W. H. Edman, Chairman, Holophane Company, Inc., Newark, Ohio.

P. B. Clark	C. H. Rex
W. B. Elmer	D. W. Rowten
C. A. B. Halvorson	G. A. Trosper
M. E. Keck	H. F. Wall
G. E. Korten	Henry Wojcik

R. R. Wylie

Traffic Safety

P. C. Box, Chairman, Barton & Associates, Inc., 600 Davis St., Evanston, Ill.

C. A. Minors	*M. D. Segal
O. P. Ortlieb	R. M. Swetland
W. E. Schwannhauser	H. F. Wall

Traffic Sign Lighting

O. W. Meissner, Chairman, Bureau of Street Lighting, 251 City Hall, Los Angeles 12, Calif.

P. C. Box	C. W. Prisk
G. W. Howie	W. E. Schwannhauser
*H. W. Osborne	V. L. Waight

R. M. Williston

Tunnels and Underpass Lighting

H. F. Wall, Chairman, Public Lighting Commission, 174 E. Atwater St., Detroit 26, Mich.

M. E. Keck	R. M. Swetland
F. J. Schmidt	D. A. Toenjes

G. A. Trosper

Visibility under Fog Conditions

E. E. Paul, Chairman, Howard, Needles, Tammen & Bergendoff, 99 Church St., New York 7, N. Y.

W. H. Edman	M. E. Keck
D. M. Finch	C. R. Marsh
J. D. Hoxie	C. H. Rex

E. R. Ricker

*Members only in advisory capacity.

SCHOOL — To study the application of light and lighting to the spaces and processes involved in educational institutions and to report thereon.

J. M. Chorlton, Chairman, Board of Education, 155 College St., Toronto 2B, Ont.

Willard Allphin	J. L. Kilpatrick
R. D. Bradley	C. N. Laupp
L. H. Brown	H. L. Logan
H. F. Davidson	J. D. MacConnell
A. A. Eastman	B. M. McLean
W. S. Fisher	J. J. Neidhart
W. V. C. Foulks	J. F. Parsons
J. W. Griffith	R. C. Putnam
J. P. Hamel	F. K. Sampson
R. C. Hultgren	Paul Seagers
L. V. James	E. M. Strong
Chester Jarrett	H. A. Stroud
W. H. Johnson	K. C. Welch

Chalkboards

H. F. Davidson, Chairman, Curtis Lighting of Canada Ltd., 195 Wickstead Ave., Leaside, Toronto, Ont.

Electric Lighting Design

J. F. Parsons, Chairman, Niagara-Mohawk Power Corp., Electric Bldg., Buffalo 3, N. Y.

Student Vision and Scholarship

A. A. Eastman, Chairman, General Electric Co., Nela Park, Cleveland 12, Ohio.

Visual Problems

Paul Seagers, Chairman, School of Education, Indiana University, Bloomington, Ind.

SEARCHLIGHT — To study the design and application of searchlights and to report thereon.

T. I. Monahan, Chairman, Naval Material Laboratory, N. Y. Naval Shipyard, Brooklyn 1, N. Y.

Fred G. Bauer	E. B. Heyer
Ernest Boghosian	George F. Johnston
F. E. Carlson	Harold Korbel
Pierre Demoureuille	J. P. Latil
R. B. Dull	Peter Mole
Carl Egeler	T. M. Monahan
B. R. Finch	W. F. Mullis
C. J. Glass	L. R. Noffsinger
D. S. Gustin	W. A. Pennow
J. S. Haney	Don Peterson
Arthur Hatch	T. H. Projector
C. A. Hearn	S. Resnick
R. Heine-Geldern	A. P. Wasdyke

LIAISON REPRESENTATIVES

J. C. Boggs	R. S. Wiseman

Light Sources

Stewart Belden	R. L. Henderson
R. Heine-Geldern	Harold Korbel
D. S. Gustin	J. P. Latil
M. A. Hankins	S. M. Segal
Arthur Hatch	A. M. Swasey

Nomenclature

Ernest Boghosian, Chairman, Dept. of the Navy, Bureau of Ships, Washington, D. C.

H. Korbel

Optics

D. Peterson, Chairman, Bausch & Lomb Optical Co., Rochester 2, N. Y.

W. Drake	B. R. Finch

E. B. Meyer

Testing Procedures

T. H. Projector, Chairman, 3304 Edgewood Rd., Kensington, Md.

Sidney Feldman	S. M. Segal

R. S. Wiseman

Visibility of Targets and Sources

J. C. Boggs	John Johnson

SIGN LIGHTING — To study the lighting of signs, both exterior and interior and report thereon.

C. N. Laupp, Chairman, Wisconsin Electric Power Co., 231 W. Michigan St., Milwaukee, Wis.

M. R. Ely	W. H. Kahler
R. E. Faucett	E. E. Kinney
H. B. Fletcher	M. F. McCann
A. L. Hart	R. J. Neu

SPORTS AND RECREATIONAL AREAS — To develop current recommended practices for lighting sports and recreational areas; study techniques of application including effects on player performance and spectator visibility and report thereon.

Wallace W. Weld, Chairman, Revere Electrical Mfg. Co., 7420 Lehigh Ave., Chicago 48, Ill.

James Bale	W. P. Graham
D. R. Brown	Howard Long
R. H. Dickinson	Edward Machtinger
R. T. Dorsey	D. L. Neer
R. E. Faucett	D. E. Trefry

H. M. White

TESTING PROCEDURES — To prepare standard test procedures for illumination characteristics of light sources, lighting equipment and illumination materials and to report thereon.

A. W. Weeks, Chairman, Champion Lamp Works, 330 Lynnway, Lynn, Mass.

Eldon H. Witte, Vice-Chairman, Benjamin Electric Mfg. Co., Des Plaines, Ill.

Paul H. Lamson, Secretary, Wheeler-Fullerton Lighting Div., Hanson, Mass.

A. J. Birkhoff	Phelps Meaker
J. E. Bock	G. A. Meyers
R. D. Bradley	W. E. Murray
R. C. Dahl	P. M. Neal
G. E. Davidson	Jack D. Pomon
D. W. Davis	Priscilla Presbrey
W. V. C. Foulks	Luke A. Provenzano
J. S. Franklin	E. H. Salter
W. G. Hill	R. L. Smith
G. A. Horton	Thomas Snaman
W. H. Houston	Kurt Stauffert
B. F. Jones	R. P. Teele
A. E. Krawcek	W. W. Weld
T. H. Leister	S. W. Wilson (alt.)
J. H. McCulloch	P. L. Young

General Guide on Photometry

R. P. Teele, Chairman, National Bureau of Standards, Washington, D. C.

Guide for Determination and Specification of Diffusion and Hiding Power of Fixture Diffusing Materials

J. H. McCulloch, Chairman, Independent Testing Laboratories, 1928 Fourteenth St., Boulder, Colo.

A. J. Birkhoff	Phelps Meaker
R. D. Bradley	P. M. Neal
G. E. Davidson	R. L. Smith

E. H. Witte

Guide for Electrical & Photometric Measurements of Fluorescent Lamps

G. A. Meyers, Chairman, Sylvania Electric Products Inc., 75 Sylvan St., Danvers, Mass.

(*Continued on page* 48A)

*Members only in advisory capacity.

SEE WHAT WIDE-LITES CAN DO!

PATENTED

Flood Entire Shopping Centers with SMOOTH, EVEN, SOFT LIGHTS!

Shopping Centers come alive at night with Wide-Lite's broad, natural light. The daylight quality of this light complements colors and gives them an appealing warmth. Its broad beam gives a smooth coverage that eliminates harsh shadows.

Wide-Lites achieve this broad beam with *exclusive rectangular reflectors.* This patented feature makes the most of efficient, color-corrected mercury vapor lighting. Rectangular light patterns overlap to provide even coverage without concentric circles, "hot spots," or dark shadows. This makes it easy to plan perimeter lighting so that the mounting poles are out of the way of traffic. Fewer poles are needed, too, because *one* Wide-Lite does the work of *two* or *more* incandescent floodlights of comparable wattage. Wide-Lites require 61% less power than ordinary incandescent floodlights and lamps last seven times as long!

Wide-Lites are cast from aluminum alloy and finished with aluminum epoxy paint for corrosion control. Tempered glass lenses completely seal lamp and reflector against dirt and moisture. And, when a Wide-Lite finally needs relamping the seal doesn't have to be broken. Sizes range from 100-watt, to 1000-watt, with a choice of reflectors and light patterns available in all models.

Get more facts—mail the coupon for a prompt reply.

WIDE-LITE

WIDE-LITE CORPORATION

P. O. Box 191 • Houston 1, Texas

In Canada: Wide-Lite Division of Wakefield Lighting, Limited, London, Canada

OUTDOOR AREA LIGHTS • VAPOR TITE MODELS • INDOOR LUMINAIRES
MOBILE WORKING LIGHTS • SPORTS LIGHTS • PROTECTIVE LIGHTS

WIDE-LITE CORPORATION
P. O. Box 191 • Houston 1, Texas

Please send me more information on Wide-Lites. No obligation, of course.

Name _____

Address _____

City _____ Zone _____ State _____

(*Continued from page 46A*)

G. E. Davidson — T. H. Leister
J. S. Franklin — Priscilla Presbrey
W. G. Hill — E. H. Salter
W. H. Houston — Kurt Stauffert
E. M. Kooker — A. W. Weeks
S. W. Wilson

Guide for Electrical and Photometric Measurements of Mercury Lamps

J. S. Franklin, Chairman, General Electric Co., Hendersonville, N. C.

Guide for Interpretation of Test Data and Results

J. S. Franklin, Chairman, General Electric Co., Hendersonville, N. C.

R. D. Bradley — A. E. Krawcek
G. E. Davidson — T. H. Leister
D. W. Davis — Phelps Meaker
W. V. C. Foulks — G. A. Meyers
J. S. Franklin — E. H. Salter
G. A. Horton — R. L. Smith
E. H. Witte

Guide for Investigation of Methods and Techniques of Measuring and Reporting Tests of Reflector Type Lamps

Priscilla Presbrey, Chairman, Westinghouse Electric Corp., Bloomfield, N. J.

G. E. Davidson — S. M. Gray
C. D. Foss — Harry Koth
J. S. Franklin — A. E. Krawcek
G. A. Freeman — E. H. Salter
Kurt Stauffert

Guide for Life Performance Testing of Fluorescent Lamps

Priscilla Presbrey, Chairman, Westinghouse Electric Corp., Bloomfield, N. J.

G. E. Davidson — E. H. Salter
W. G. Hill — G. R. Spears
W. H. Houston — Kurt Stauffert
E. M. Kooker — A. W. Weeks
S. W. Wilson

Guide for Method of Measurement of Fluorescent Lamp Starting

G. A. Meyers, Chairman, Sylvania Electric Products Inc., 75 Sylvan St., Danvers, Mass.

T. H. Heine — E. M. Kooker
W. H. Houston — Kurt Stauffert
A. W. Weeks

Guide for Outdoor Illumination Tests

J. S. Franklin, Chairman, General Electric Co., Hendersonville, N. C.

Guide for Photometric and Electric Testing Measurements and Life Testing of Incandescent Lamps

W. E. Murray, Chairman, Los Angeles Dept. of Water and Power, Box 3669, Terminal Annex, Los Angeles 54, Calif.

C. D. Foss — E. H. Salter
W. H. Houston — Kurt Stauffert
Phelps Meaker — Paul Townsend

Guide for Photometric Testing of Floodlights of 10°-160° Total Beam Spread (1950)

J. S. Franklin, Chairman, General Electric Co., Hendersonville, N. C.

J. E. Bock — L. A. Provenzano
G. E. Davidson — E. H. Salter
G. A. Horton — Kurt Stauffert
A. E. Krawcek — W. W. Weld
Jack D. Pomon — E. H. Witte

Guide for Photometric Testing of Fluorescent Luminaires

G. A. Horton, Chairman, Westinghouse Electric Corp., 1216 W. 58th St., Cleveland 1, Ohio.

R. D. Bradley — J. H. McCulloch
G. E. Davidson — Phelps Meaker
Donald W. Davis — F. M. Neal
D. M. Finch — E. H. Salter
W. V. C. Foulks — R. L. Smith
P. H. Lamson — W. W. Weld
E. H. Witte

Guide for Photometric Testing of Mercury, Sodium and Incandescent Street Lighting Luminaires

T. H. Leister, Chairman, Line Materials Industries, 12th & Madison Avenues, South Milwaukee, Wis.

R. C. Dahl — J. D. Pomon
G. E. Davidson — L. A. Provenzano
J. S. Franklin — E. H. Salter
G. A. Horton — R. L. Smith
F. M. Neal — W. W. Weld
P. L. Young

Guide for Photometric Testing of Outdoor Luminaires

J. S. Franklin, Chairman, General Electric Co., Hendersonville, N. C.

Guide for Photometry of Searchlights

A. E. Krawcek, Chairman, Crouse-Hinds Co., Syracuse 1, N. Y.

Guide for Reporting Lighting Equipment Engineering Data

E. H. Witte, Chairman, Benjamin Electric Mfg. Co., Des Plaines, Ill.

Guide for Testing Filament Luminaires

E. H. Salter, Chairman, Electrical Testing Laboratories, 2 East End Ave., N. Y., N. Y.

Guide for Use of Photoelectric Portable Photometers (1937)

G. A. Horton, Chairman, Westinghouse Electric Corp., 1216 W. 58th St., Cleveland 1, Ohio.

A. J. Birkhoff — Phelps Meaker
G. A. Meyers

Practical Guide for Brightness Measurements

P. H. Lamson, Chairman, Wheeler-Fullerton Lighting Div., Hanson, Mass.

R. D. Bradley — J. H. McCulloch
G. E. Davidson — L. A. Provenzano
D. W. Davis — E. H. Salter
G. A. Horton — R. P. Teele
B. F. Jones — E. H. Witte

Practical Guide to Colorimetry of Light Sources

R. P. Teele, Chairman, National Bureau of Standards, Washington, D. C.

M. H. Gabriel — L. A. Provenzano
W. H. Houston — A. W. Weeks

Practical Guide to Photometry

R. D. Bradley, Chairman, Day-Brite Lighting Inc., 5411 Bulwer Ave., St. Louis 7, Mo.

A. J. Birkhoff — T. H. Leister
G. E. Davidson — L. A. Provenzano
W. G. Hill — Kurt Stauffert
G. A. Horton — A. W. Weeks
B. F. Jones — P. L. Young

Study Project A—To establish methods of testing heavily loaded lamps and auxiliary equipment with respect to distribution and physical orientation.

G. A. Horton, Chairman, Westinghouse Electric Corp., 1216 W. 58th St., Cleveland 1, Ohio

G. E. Davidson — G. A. Meyers
M. H. Lakness — R. L. Smith

Study Project B—To establish methods of measurement and temperature and drafts with respect to fluorescent lamps and auxiliary equipment.

G. A. Meyers, Chairman, Sylvania Electric Products Inc., 75 Sylvan St., Danvers, Mass.

R. D. Bradley — Philip R. Herrick
G. E. Davidson — W. H. Houston
J. S. Franklin — A. W. Weeks

Study Project C—To follow ballast testing techniques.

R. D. Bradley, Chairman, Day-Brite Lighting, Inc., 5411 Bulwer Ave., St. Louis, Mo.

G. E. Davidson — J. H. McCulloch
Paul H. Lamson — E. H. Salter
A. W. Weeks

THEATRE-TELEVISION — To study and report on the lighting for theatrical presentations and for production of television programs.

Joel E. Rubin, Chairman, Kliegl Bros., 321 W. 50th St., New York, N. Y.

Alfred W. Boylen — Herbert More
C. S. Bramley — Thomas Nutt
T. W. Butler — Walter O'Meara
Frank E. Carlson — Kenneth M. Palius
Ariel R. Davis — Arthur C. Risser
Gilbert J. deStefano — Jean Rosenthal
D. W. Frick — Hunton D. Sellman
Theodore Fuchs — George C. Smedberg
Walter H. Garrett, Jr. — Rollo G. Williams
George T. Howard — Willett R. Wilson
Herbert A. Kliegl — Robert L. Zahour

IES-SMPTE Recommended Practice

A. C. Risser, Chairman, University of Wichita, Wichita, Kans.

D. W. Frick — G. T. Howard

Lighting for School Theatres

R. G. Williams, Chairman, Century Lighting, Inc., 521 West 43rd St., New York 36, N. Y.

A. W. Boylen — T. Fuchs
A. R. Davis — A. C. Risser
H. D. Sellman

Lighting for the Vidicon Camera

H. R. More, Chairman, Kliegl Bros., 321 West 50th St., New York, N. Y.

C. S. Bramley — W. O'Meara
D. W. Frick — K. M. Palius
R. L. Zahour

Theatre Lighting Glossary

A. R. Davis, Chairman, Ariel Davis Mfg. Co., 3687 S. State St., Salt Lake City, Utah.

OFFICIAL REPRESENTATIVES TO OTHER ORGANIZATIONS

AMERICAN STANDARDS ASSOCIATION SECTIONAL COMMITTEES

(C. L. Crouch, Technical Director, alternate representative to all)

Building Exits Code, A9
H. E. D'Andrade

American Standard Practice for Industrial Lighting, A11
L. G. Parks

American Standard Practice for School Lighting, A23
J. M. Chorlton

Building Code Requirements for Light and Ventilation, A53
J. W. Griffith

National Electrical Code, C1
Panel 2, 3 and 10
G. E. Shoemaker

Definitions of Electrical Terms, C42
Priscilla Presbrey

Dimensional and Operational Standardization of Electrical Lamps and Auxiliaries for Gaseous Discharge Lamps, C78
Thomas S. Kelly

Inspection Requirements for Motor Vehicles, D7.1
R. P. Teele

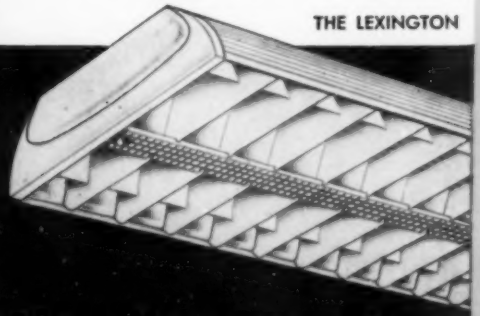
Office Standard, X2
Subcommittee #1, Office Equipment (Furniture)
Subcommittee #2, Office Papers
Subcommittee #5, Business Machines
Eric H. Church

(*Continued on page 54A*)

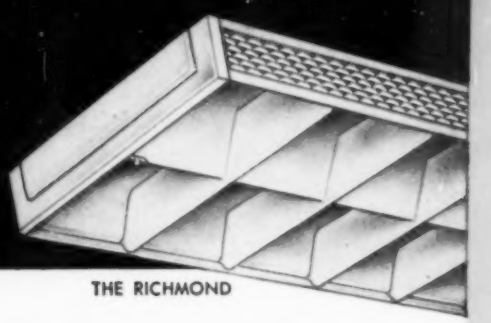
Now Available for
1960 SCHOOL PROJECTS

- **New Construction**
- **Renovation**

THE LEXINGTON



New Improved RICHMOND and LEXINGTON ...at New Low Prices



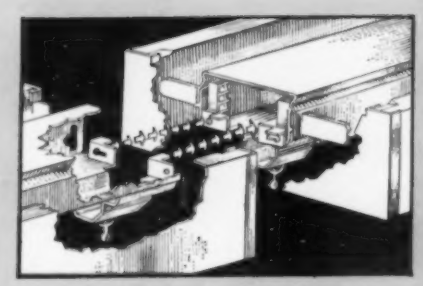
THE RICHMOND

The newly Improved Richmond and Lexington Series by Miller offer outstanding Values for lighting Schools, Offices, and Stores.

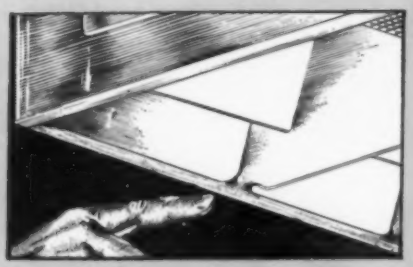
Four exclusive *installation and maintenance features* have been built into all units in both series. *Prices for most types are at new lows,* while illumination performance remains high as ever. Trimmer, more modern appearance is another plus.

You can choose between 45° x 45° or 35° x 25° shielding for both series; 2 or 4 Lp., in 4 or 8 foot lengths. *Power-Groove* operation is a brand new option for the 2 Lp. Richmond.

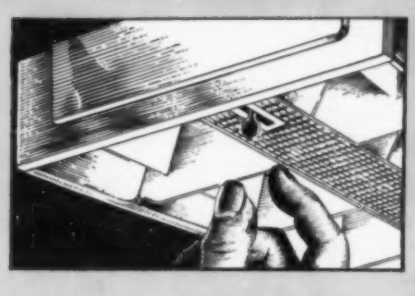
For complete catalog information mail coupon or write Dept. RL 460. For a physical demonstration contact your Miller Representative, or your Miller Distributor.



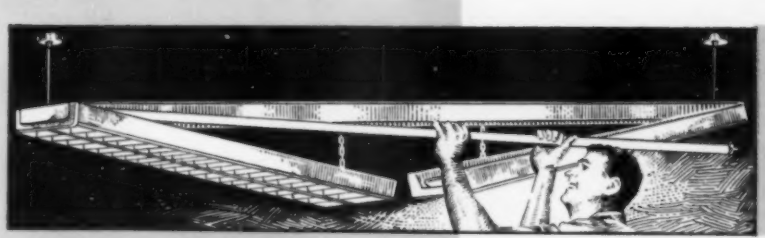
Sure Alignment . . .
Built-in Connector



Rigid, Rattle-free
Shielding Assembly



Sure Locking, Visual
Action Latches



Easily Relamped from Single Ladder Position

MAIL TODAY

To: Dept. RL-460
THE MILLER COMPANY, Meriden, Conn.

- ☐ I'd like additional information about The New, Improved RICHMOND & LEXINGTON Lighting Fixtures.
- ☐ Have Your Field Representative contact me.

Name..... Position.....

Company.....

Street.....

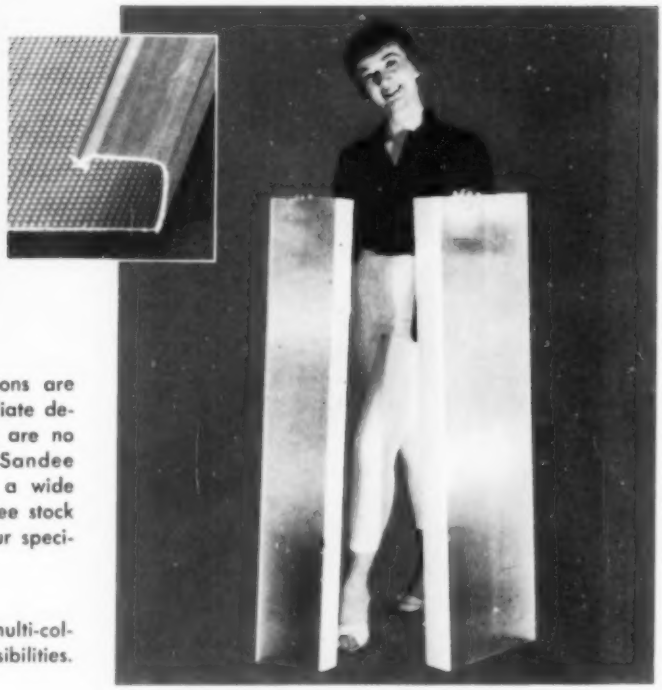
City..... State.....

LIGHTING BY
miller
SINCE 1844

THE **miller** COMPANY
MERIDEN, CONNECTICUT • UTICA, OHIO

Sandee POLY-LITE®

PANELS for fluorescent lighting fixtures

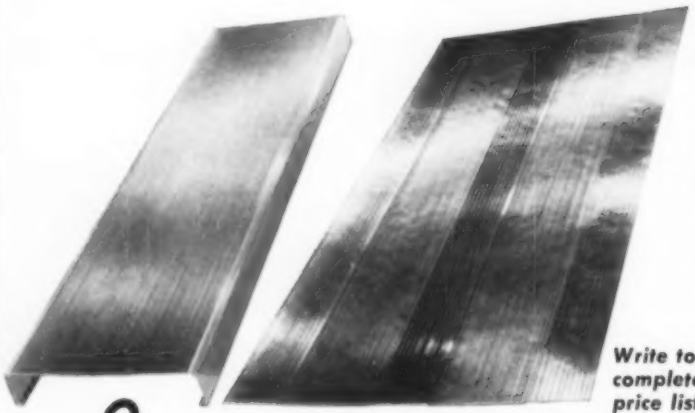


STOCK SECTIONS (Above)

Many Sandee Poly-Lite® standard sections are carried in regular stock — you get immediate delivery without paying a premium. There are no die costs or set up charges on any Sandee Poly-Lite® stock panels — yet you have a wide variety of patterns to choose from. Sandee stock Poly-Lite® panels are supplied cut to your specifications.

2 COLOR EXTRUSIONS (Right)

New thinking and new applications in multi-colored extrusions offer unlimited design possibilities.



CUSTOM SECTIONS (Far left)

You create it . . . We'll make it. There is no substitute for the experience Sandee has gained thru the years. Our experienced technicians and skilled craftsmen are at your service.

EMBOSSED PATTERNS (Left)

We have what the industry needs for good lighting . . . Hiding power, low brightness, diffusion and high efficiency.

Write today for a copy of our complete extrusion folder and price lists.

Phone NEvada 8-6655

Sandee MANUFACTURING COMPANY

735 SOUTH KARLOV AVE. • CHICAGO 24, ILLINOIS

I. E. S. National and Local Officers, 1959-1960

Officers and Council 1959-1960

President — J. B. BROWDER, Georgia Power Co., 75 Marietta St., N. W., Atlanta, Ga.
Vice-President — R. G. SLAUER, Sylvania Electric Products, Inc., One 48th St., Wheeling, W. Va.
Vice-President — J. R. CHAMBERS, Appleton Electric Co., 1701-1759 Wellington Ave., Chicago, Ill.
Past-President — G. J. TAYLOR, Day-Brite Lighting, Inc., 212 So. Central Ave., Clayton 5, Mo.
Past-President — K. M. REID, General Electric Co., Nela Park, Cleveland, Ohio.
General Secretary—G. FRANKLIN DEAN, Toronto Hydro-Electric System, 14 Carlton St., Toronto, Ont.
Treasurer—W. P. LOWELL, JR., Sylvania Electric Products, Inc., 60 Boston St., Salem, Mass.

Directors

CHARLES L. AMICK, Day-Brite Lighting, Inc., P.O. Box 141, St. Louis, Mo.
J. SAMUEL HAMEL, 1122 Rossmoyne St., Glendale, Calif.
J. DIXON MITCHELL, Westinghouse Lamp Division, 2260 Peachtree Industrial Blvd., Chamblee, Ga.
R. P. TEELE, National Bureau of Standards, Washington, D. C.
JOSEPH THOMAS, Canadian General Electric Co., Ltd., 280 Faillon St., Montreal, Que.
J. D. WHITNELL, Arizona Public Service Co., P. O. Box 2591, Phoenix, Ariz.

Regional Vice-Presidents

Canadian Region—JOHN M. CHORLTON, Toronto Board of Education, 155 College St., Toronto 2B, Ont.
East Central Region—C. D. MILLER, Duquesne Light Co., 435 Sixth Ave., Pittsburgh, Pa.
Great Lakes Region — R. W. BROWN, Cincinnati Gas & Electric Co., 4th & Main Sts., Cincinnati, Ohio.
Inter-Mountain Region — L. S. REED, L. S. Reed & Co., 1018 Lawrence, Denver, Colo.
Midwestern Region — BROOKS CHASSAING, Chassaing Brothers Lighting, 7603 Forsyth Blvd., Clayton, Mo.
Northeastern Region — R. L. SMART, Boston Edison Co., 39 Boylston St., Boston, Mass.
Pacific Northwest Region — BEVERLY TRAVIS, 1117 Second Ave. Bldg., Seattle, Wash.
South Central Region — J. M. GENSBURGER, New Orleans Public Sevice, Inc., 317 Baronne St., New Orleans, La.
Southeastern Region — C. L. CANNON, 155 Nassau St., N. W., Atlanta, Ga.
South Pacific Coast Region — J. E. BARNES, Pacific Gas & Electric Co., P. O. Box 540, San Rafael, Calif.
Southwestern Region — JOHN B. DECK, JR., General Electric Supply Co., P. O. Box 5504, Dallas 22, Texas.

Section and Chapter Officers 1959-1960

Alabama Section—South Central Region
Chairman — M. R. HAZZARD, Hazzard, McRay & Cone, 3015 Sixth Ave. S., Birmingham, Ala.
Secretary — R. D. STEELE, Alabama Power Co., 2100 1st Ave. N., Birmingham 2, Ala.

Alamo Section—Southwestern Region
Chairman — KENNETH L. COTTON, 434 So. Main Ave., San Antonio, Texas.
Secretary — L. W. TRAVIS, Beretta, Greenslade & Assoc. Inc., 1927 N. St. Mary's, San Antonio, Texas

Arizona Section—Inter-Mountain Region
Chairman — ROBERT W. GODEMANN, Arizona Public Service Co., P. O. Box 2591, Phoenix, Ariz.
Secretary — WILLIAM BENNDORF, 221 E. Camelback Rd., Phoenix, Ariz.

Arkansas Chapter—South Central Region
Chairman — W. R. SIMPSON, Arkansas Power & Light Co., 123 W. 4th St., Little Rock, Ark.
Secretary — S. J. LAVENDER, Tri-State Mill Supply Co., 224 Mulberry, Pine Bluff, Ark.

Ark-La-Tex Chapter—Southwestern Region
Chairman — R. DON MADDEN, Southwestern Electric Power Co., 428 Travis, Shreveport, La.
Secretary—RALPH P. NIX, Southwestern Electric Power Co., P. O. Box 1106, Shreveport, La.

Arrowhead Chapter—South Pacific Coast Region
Chairman—W. H. RITTER, JR., California Electric Power Co., P. O. Box 1029, San Bernardino, Calif.
Secretary — G. F. BURGESS, California Electric Power Co., 2885 Foothill Blvd., San Bernardino, Calif.

Bluenose Chapter—Canadian Region
Chairman—W. J. PHILLIPS, Nova Scotia Light & Power Co. Ltd., P. O. Box 848, Halifax, N. S.
Secretary — J. G. FERRARIS, P. O. Box 102, Armdale P. O., Halifax, N. S.

British Columbia Section—Pacific Northwest Region
Chairman—H. G. FOSTER, Northern Electric Co., Ltd., 8325 Fraser St., Vancouver, B. C.
Secretary — W. J. BUTLER, B. C. Electric Co., Ltd., 970 Burrard St., Vancouver, B. C.

Buckeye Chapter—Great Lakes Region
Chairman — B. D. RUSSELL, Columbus & Southern Ohio Electric Co., 215 N. Front St., Columbus, Ohio.
Secretary — M. J. LEAHY, M. J. Leahy Co., 1089 Elmore Ave., Columbus, Ohio.

Capital Section—East Central Region
Chairman—EDMUND F. BAILER, General Electric Co., 777 14th St., N. W., Washington 5, D. C.
Secretary — C. E. O'DANIEL, Potomac Electric Power Co., 929 E St., N. W., Washington, D. C.

Central Florida Chapter—Southeastern Region
Chairman — LOWRY MILLER, Florida Power Corp., 515 Park Ave., Winter Park, Fla.
Secretary—JOHN E. OLIVE, Palmer Electric Co., 875 Jackson, Winter Park, Fla.

Central Illinois Chapter—Midwestern Region
Chairman — H. G. YOUNG, Kiefer Electrical Supply Co., 318-320 S. W. Washington, Peoria, Ill.
Secretary — ROBERT J. ZUCKER, Westinghouse Electric Corp., 2800 N. Adams, Peoria, Ill.

Central Kansas Chapter—Midwestern Region
Chairman — CARL GREEN, Carl Green & Associates, 1542 S. St. Francis, Wichita, Kans.
Secretary — FRANK EDDINS, Kansas Gas & Electric Co., P. O. Box 208, Wichita, Kans.

Central New York Section—Great Lakes Region
Chairman—ROBERT CARYL, Donohoe & Caryl, Airport Road, Syracuse, N. Y.
Secretary — DONALD R. BROWN, Crouse-Hinds Co., Wolf & 7th North Sts., Syracuse, N. Y.

Central Oklahoma Chapter—Southwestern Region
Chairman — ROBERT B. GOW, Oklahoma Gas & Electric Co., 321 N. Harney St., Oklahoma City, Okla.
Secretary—GRANT K. LANDON, Oklahoma City Board of Education, 900 N. Klein, Oklahoma City, Okla.

Chicago Section—Midwestern Region
Chairman — BENJAMIN F. AVERY, General Electric Co., 165 N. Canal St., Chicago, Ill.
Secretary — ELDON H. WITTE, Benjamin Electric Mfg. Co., Des Plaines, Ill.

Chinook Chapter—Pacific Northwest Region
Chairman — W. WARRACK, Warrack Electric, 814 16th Ave., N. W., Calgary, Alta.
Secretary — NIELS JOHANSEN, J. Stevenson & Associates, 344 12th Ave., S. W., Calgary, Alta.

Cleveland Section—Great Lakes Region
Chairman—J. G. MITCHELL, Grant Electric Co., 3016 Payne Ave., Cleveland, Ohio.
Secretary — L. S. STERNBERG, Midland Electric Co., 2125 Superior Ave., Cleveland, Ohio.

Coastal Bend Chapter—Southwestern Region
Chairman—L. H. KINDEL, Central Power & Light Co., 120 N. Chaparral, Corpus Christi, Texas.
Secretary — A. D. WILLIAMS, General Electric Co., 1630 S. Brownlee, Corpus Christi, Texas.

Coastal Empire Chapter—Southeastern Region
Chairman — LLOYD L. BLACK, Graybar Electric Co., Inc., 532 Indian St., Savannah, Ga.
Secretary — LEON R. CASE, JR., Savannah Electric & Power Co., P. O. Box 949, Savannah, Ga.

Connecticut Section—Northeastern Region
Chairman — W. P. CARPENTER, The Superior Electric Co., 83 Laurel St., Bristol, Conn.
Secretary — ROBERT H. CHASE, Hartford Electric Light Co., 266 Pearl St., Hartford, Conn.

Cornhusker Section—Midwestern Region
Chairman—H. J. PALMER, JR., Iowa Public Service Co., Orpheum-Electric Bldg., Sioux City, Ia.
Secretary — ROBERT W. BREWER, Iowa Public Service Co., Box 778, Sioux City, Ia.

Diablo Section—South Pacific Coast Region
Chairman—G. N. RADFORD, Pacific Gas & Electric Co., 1625 Clay St., Oakland, Calif.
Secretary—WALKER BROWN, Weld-Rite Co., 4417 Oakport St., Oakland, Calif.

Eastern New York Section—Northeastern Region
Chairman — JOHN M. HARNEY, Smith Electric Co., Inc., 110 Remsen St., Cohoes, N. Y.
Secretary — CHARLES E. WALDRON, Niagara Mohawk Power Corp., 126 State St., Albany, N. Y.

Eastern Pennsylvania Section—East Central Region
Chairman—RICHARD A. REYNOLDS, 2704 Hillvale Ave., West Lawn, Pa.
Secretary — J. H. BICHER, General Electric Supply Co., 1041 Rockland St., Reading, Pa.

(*Continued on page* 52A)

(Continued from page 51A)

Edmonton Section—Pacific Northwest Region
Chairman — D. A. TUCKER, Western Electrical Constructors, 316 Northern Hardware Bldg., Edmonton, Alta.
Secretary — H. E. MATHER, Alberta Electrical Supplies, Ltd., 10168 106th St., Edmonton, Alta.

Florida Section—Southeastern Region
Chairman—K. D. BRUMBAUGH, Kenneth D. Brumbaugh & Associates, 3128 Southgate Circle, Sarasota, Fla.
Secretary — SEYMOUR BELL, Sarasota Electric Corp., 1021 Central Ave., Sarasota, Fla.

Forest City (London) Chapter—Canadian Region
Chairman—W. DODD, J. E. Dufton Lighting Fixtures, 26 Evergreen Ave., London, Ont.
Secretary—G. L. THEAKSTON, Wakefield Lighting Ltd., Commissioner Rd., London, Ont.

Georgia Section—Southeastern Region
Chairman — SAYLORS J. ANDRE, Georgia Power Co., P. O. Box 1719, Atlanta, Ga.
Secretary—ARTHUR H. LUNDSTROM, Whitehead Electric Co., 210 14th St., N. W., Atlanta, Ga.

Golden Gate Section—South Pacific Coast Region
Chairman—WALTER G. BAYHA, Bayha, Weir & Finato, 1045 Sansome St., San Francisco, Calif.
Secretary — ARTHUR S. TYLOR, 1037 Cortez Ave., Burlingame, Calif.

Golden West Chapter—Pacific Northwest Region
Chairman—L. H. RITENBURG, L. H. Ritenburg & Associates, P. O. Box 706, Regina, Sask.
Secretary — W. J. HEMS, Canadian General Electric Co., 105 Brent Bldg., Regina, Sask.

Gulf Coast Chapter—South Central Region
Chairman — W. T. REEVES, Moore Handley Hardware Co., Inc., 401 N. Water St., Mobile, Ala.
Secretary—J. E. SPRINGER, Alabama Power Co., 68 St. Francis, Mobile, Ala.

Hamilton, Ontario Chapter—Canadian Region
Chairman—J. W. WOODS, 665 Gayne Blvd., Van Acres, Burlington, Ont.
Secretary—TO BE APPOINTED

Heart of America Section—Midwestern Region
Chairman — ROBERT W. WILSON, Boese Hilburn Electric Co., 123 W. 8th St., Kansas City, Mo.
Secretary—CHARLES J. PURCELL, 615 W. 70th St., Kansas City, Mo.

Indiana Section—Midwestern Region
Chairman — ALFRED S. COFFIN, JR., Public Service Co. of Indiana, Inc., 1000 East Main, Plainfield, Ind.
Secretary—M. B. WOLFE, Keppler Sales, 714 State Life Bldg., Indianapolis, Ind.

Inland Empire Chapter—Pacific Northwest Region
Chairman—HARRY B. LOBDEL, Columbia Electric & Mfg. Co., 2310 N. Fancher Way, Spokane, Wash.
Secretary — RAY D. ROOKEY, Washington Water & Power Co., West 825 Trent, Spokane, Wash.

Iowa Section—Midwestern Region
Chairman— MARY E. STAFFORD, Thomas Electric Co., 816 Locust St., Des Moines, Ia.
Secretary — L. J. KINGSLEY, Crescent Electric Supply Co., 313 S. W. 5th St., Des Moines, Ia.

Kentuckiana Chapter—Great Lakes Region
Chairman—LOUIS A. BULLIET, E. R. Ronald & Associates, 554 South Third, Louisville, Ky.
Secretary—JOSEPH HOWARD, General Electric Co., 3620 Lexington Rd., Louisville, Ky.

Maritime Chapter—Canadian Region
Chairman—E. J. WILCOX, 20 Alexander St., St. John, N. B.
Secretary — RALPH W. MCFARLANE, Electric Service League, 1 Dock St., St. John, N. B.

Maryland Section—East Central Region
Chairman — JAMES D. SMITH, General Electric Co., 1401 Parker Road, Baltimore, Md.
Secretary—SIMON E. EHRLICH, Excello Public Service Corp., 111 W. Redwood St., Baltimore 1, Md.

Miami Valley Section—Great Lakes Region
Chairman—GLENN A. GRIER, Dayton Power & Light Co., 25 No. Main St., Dayton, Ohio.
Secretary — STANLEY L. BURNHAM, General Electric Co., 225 N. Wilkenson, Dayton, Ohio.

Michigan Section—Great Lakes Region
Chairman — EDMUND W. PRATT, Detroit Edison Co., 2000 2nd Ave., Detroit, Mich.
Secretary — WALTER A. HEDRICH, University of Michigan, Ann Arbor, Mich.

Mid-South Chapter—South Central Region
Chairman—C. D. HOOPER, Memphis Light, Gas & Water Div., 179 Madison, Memphis, Tenn.
Secretary — GEORGE R. PATTERSON, Factory Sales Agency, 4776 Welchshire Ave., Memphis, Tenn.

Milwaukee Section—Midwestern Region
Chairman — ROBERT J. PRESENT, 743 N. 4th St., Milwaukee, Wis.
Secretary — CLARENCE A. KNOERR, Knoerr & Fischer, Inc., 1015 N. Milwaukee St., Milwaukee, Wis.

Mississippi Chapter—South Central Region
Chairman—C. E. STRAHAN, JR., Mississippi Power & Light Co., 144 S. Congress St., Jackson 5, Miss.
Secretary — STEPHEN H. TURNER, Mississippi Power & Light Co., 144 South Congress, Jackson, Miss.

Montreal Section—Canadian Region
Chairman—JOHN E. SHEPHERD, Lighting Materials Ltd., 555 40th Ave., Ville La Salle, Que.
Secretary—W. G. MOORE, Electrolier Mfg. Co., Ltd., 5849 Boyer St., Montreal, Que.

Mother Lode Chapter—South Pacific Coast Region
Chairman — EARL E. STORRS, Industrial Electrical Consultant, P. O. Box 167, Stockton, Calif.
Secretary — JOHN C. ZEHMS, Pacific Gas & Electric Co., 1050 High St., Auburn, Calif.

New England Section—Northeastern Region
Chairman—LEONARD A. BEAN, 14 Hancock St., Bedford, Mass.
Secretary—PAUL M. CROSBY, Cambridge Electric Light Co., 46 Blackstone, Cambridge, Mass.

New Jersey Section—Northeastern Region
Chairman — JOHN F. MACDOUGALL, General Electric Co., 744 Broad St., Newark, N. J.
Secretary — J. I. HARGIS, Day-Brite Lighting, Inc., P. O. Box 349, Bloomfield, N. J.

New Mexico Chapter—Inter-Mountain Region
Chairman — OLEN PEDDY, Public Service Co. of N. M., P. O. Box 1360, Albuquerque, N. M.
Secretary — JAMES J. HALLEK, 4204 Palo Duko, N. E., Albuquerque, N. M.

New Orleans Section—South Central Region
Chairman — GEORGE J. SEGAL, New Orleans Public Service, Inc., 317 Baronne St., New Orleans, La.
Secretary — JAMES A. STELLY, Gulf States Utilities Co., 446 North Blvd., Baton Rouge, La.

New York Section—Northeastern Region
Chairman — WILLIAM H. KEEN, General Electric Co., 570 Lexington Ave., New York, N. Y.
Secretary — ROLLO G. WILLIAMS, Century Lighting, Inc., 521 W. 43rd St., New York, N. Y.

North Texas Section—Southwestern Region
Chairman—PAUL A. CRICK, Trade Mart, Rm. 2000, 2100 Stemmons Expressway, Dallas 7, Texas.
Secretary—WILLIAM T. KIMERY, Dallas Power & Light Co., 1506 Commerce, Dallas, Texas.

Northumberland Chapter—Canadian Region
Chairman—MAX L. HIGGS, T. Eaton Co., Foundry St., Moncton, N. B.
Secretary—BENOIT LAVIGNE, 197 West Lane, Moncton, N. B.

Northwestern Ohio Section—Great Lakes Region
Chairman — H. W. TEELE, JR., Toledo Edison Co., Edison Bldg., Toledo, Ohio.
Secretary—AUDREY C. WEGENER, Toledo Edison Co., Edison Bldg., Toledo 4, Ohio.

Ohio Valley Section—Great Lakes Region
Chairman — FRED B. MACRAE, Edwin F. Guth Co., 6503 Tyne Ave., Cincinnati, Ohio.
Secretary—HAROLD J. GRUBER, Cincinnati Gas & Electric Co., 4th & Main Sts., Cincinnati 2, Ohio.

Oil Capital Section—Southwestern Region
Chairman — RICHARD ALMOND, Almond Electric Co., 1005 E. 4th, Tulsa, Okla.
Secretary—JOHN C. PENAFEATHER, 745 So. 90 East Ave., Tulsa, Okla.

Oregon Section—Pacific Northwest Region
Chairman—JOHN A. SCHULTER, 411 Weatherly Bldg., Portland, Ore.
Secretary — W. GLENN PRACEJUS, General Electric Co., 2800 N. W. Nela, Portland, Ore.

Ottawa Section—Canadian Region
Chairman — ANDREW D. MILLER, 1122 Bedbrooke St., Ottawa, Ont.
Secretary—STEPHEN A. DAWSON, Amalgamated Electric Corp., Ltd., 46 Elgin St., Ottawa, Ont.

Ozark Chapter—Midwestern Region
Chairman — HAROLD STAHL, Lamons Electric Co., 1950 S. Glenstone, Springfield, Mo.
Secretary—C. G. WELLS, Harry Cooper Supply Co., Springfield, Mo.

Palmetto Section—Southeastern Region
Chairman—R. L. ADAMS, South Carolina Electric & Gas Co., 1309 Hampton St., Columbia, S. C.
Secretary—MIREILLI W. THOMPSON, General Electric Co., East Flatrock, N. C.

Panhandle Chapter—Southwestern Region
Chairman—GORDON BALDRY, Graybar Electric Co., P. O. Box 2868, Amarillo, Texas.
Secretary — OTHO W. WALKER, Nunn Electric Supply Corp., 105 Polk, Amarillo, Texas.

Philadelphia Section—East Central Region
Chairman—WILLIAM P. GRAHAM, Philadelphia Electric Co., 211 S. Broad St., Philadelphia, Pa.
Secretary—STANLEY W. PURDUM, Philadelphia Electric Co., 211 S. Broad St., Philadelphia, Pa.

Pittsburgh Section—East Central Region
Chairman — DONALD C. THOMAS, 124 Barbour Drive, Pittsburgh, Pa.
Secretary — HENRY J. MAZUR, Westinghouse Electric Corp., 306 4th Ave., Pittsburgh, Pa.

Puget Sound Section—Pacific Northwest Region
Chairman — JACK H. WELLS, 3405 Kromer Ave., Everett, Wash.
Secretary — JAMES A. FREDRICKSON, General Electric Co., 10 W. Connecticut, Seattle, Wash.

Quebec Chapter—Canadian Region
Chairman—GERALD DUNNIGAN, Northern Electric Co. Ltd., P. O. Box 1573, Quebec, Que.
Secretary—CLEMENT HEROUX, Quebec Power Co., 399 St. Joseph St. E., Quebec, Que.

(Continued on page 54A)

THESE AUTHORIZED LIGHTOLIER DISTRIBUTORS STOCK PRISMALUX BY LIGHTOLIER

ALABAMA
Birmingham: Mayer Elec. Sup. Co.

ARIZONA
Phoenix: Brown Wholesale Elec.
Tucson: Beacon Ltg. Fix. Co.

CALIFORNIA
San Francisco: California Elec. Sup. Co.

COLORADO
Denver: Central Elec. Sup. Co.

CONNECTICUT
Bridgeport: D. W. Tower Co., Inc.
Hartford: Beacon Light & Sup. Co.
New Haven: Grand Light & Sup. Co.
New London: United Elec. Sup. Co.
Stamford: Marie Co.
Waterbury: Starbuck Sprague Co.
Suburban Supply Co.

DISTRICT OF COLUMBIA
Washington: Maurice Elec. Sup. Co.
National Elec. Ltg., Inc.

FLORIDA
Miami: Farrey's Whlse. Hdwe. Co.

GEORGIA
Atlanta: Electrical Wholesalers
Noland Co.
Augusta: Hart Electric Sup. Co.

ILLINOIS
Chicago: Efengee Elec. Sup. Co.
Englewood Elec. Sup. Co.
Harlo Elec. Sup. Co. Inc.
Hyland Elec. Sup. Co.
Metropolitan Elec. Sup.
Steiner Elec. Co.
Wholesale Elec. Sup. Co.
Elgin: Fox Elec. Sup. Co.
Rockford: Englewood Elec. Sup. Co.
Springfield: Springfield Elec. Sup. Co.

INDIANA
Ft. Wayne: Mossman-Yarnelle Co.
Gary: Englewood Elec. Sup. Co.
South Bend: Englewood Elec. Sup. Co.

IOWA
Des Moines: Weston Lighting, Inc.

KANSAS
Kansas City: W. T. Foley Elec. Co.

KENTUCKY
Louisville: Henry J. Rueff Co.

LOUISIANA
Baton Rouge: Electrical Wholesalers Inc.
New Orleans: Interstate Elec. Co.

MAINE
Bangor: Standard Elec. Co.
Portland: Holmes Elec. Supply Co.

MARYLAND
Baltimore: Excello Public Serv. Corp.
Salisbury: Artcraft Elec. Sup. Co.

MASSACHUSETTS
Boston: Mass. Gas & Elec. Light Co.
Henry L. Wolfers, Inc.
Pittsfield: Carr Supply Co.
Springfield: Eastern Elec. Sup. Co.
Worcester: Atlantic Elec. Sup. Co.
Benjamin Elec. Sup. Co.

MICHIGAN
Detroit: Madison Elec. Co.
Michigan Chandelier Co.
Flint: Royalite Co.
Grand Rapids: Purchase Elec. Sup. Co.
Jackson: Electric Wholesale Sup. Co.
Pontiac: Standard Elec. Co.
Saginaw: Schoenherr Elec. Co.
Standard Elec. Sup. Co.

MINNESOTA
Duluth: Northern Elec. Sup. Co.
Minneapolis: Charles A. Anderson & Co.
Northland Elec. Sup. Co.
St. Paul: Lax Elec. Co.

MISSOURI
Kansas City: Glanzo Elec.
St. Louis: M. R. Clark

MONTANA
Great Falls: Glacier State Elec.

NEBRASKA
Lincoln: White Elec.
Omaha: Electric Fix. & Sup. Co.

NEVADA
Reno: Western Elec. Dists. Co

NEW HAMPSHIRE
Portsmouth: Mass. Gas & Elec. Light Co.

NEW JERSEY
Atlantic City: Franklin Elec. Sup. Co.
Cherry Hill: *Delaware Township:* Flynn's Camden Elec. Fix. Co.

NEW MEXICO
Albuquerque: The Lighting and Main. Co.

NEW YORK
Binghamton: Freije Elec. Sup. Co.
Buffalo: Buffalo Incand. Light Co. Inc.

NEW YORK (cont.)
Niagara Falls: Hyson Supplies Inc.
Poughkeepsie: Electra Sup. Co.
Rochester: Rowe Electric Sup. Co.
Syracuse: Superior Elec. Corp.

NORTH CAROLINA
Charlotte: Independent Elec. Sup. Co.
Durham: Noland Co.
Greensboro: Elec. Sup. & Equip. Co.
Kinston: Kinston Elec.
Winston Salem: Noland Co.

NORTH DAKOTA
Fargo: Northwest Elec. Sup. Inc.

OHIO
Akron: The Sacks Elec. Sup. Co.
Canton: Electric Sales Co.
Cincinnati: B. & B. Elec. Co.
F. D. Lawrence Electric Co.
Richards Elec. Sup. Co.
Cleveland: The H. Leff Electric Co.
Midland Elec. Co.
Columbus: Elgee Elec. Co.
The Loeb Elec. Co.
Dayton: Duellman Elec. Co.
Springfield: The W. W. Elec. Co.
Toledo: Gross Elec. Fix. Co.
Youngstown: Mark Industries

OKLAHOMA
Oklahoma City: Elec. Sup. of Oklahoma

OREGON
Portland: Baum Barkon Co.

PENNSYLVANIA
Allentown: Coleman Elec. Co.
Erie: Kraus Elec. Co.
Harrisburg: Fluorescent Sup. Co.
Hazleton: Power Elec. Co. Inc.
New Castle: Midwestern Elec. Co.
Philadelphia: Ace Lighting Fix. Co.
Gold Seal Elec. Sup. Co.
Sylvan Elec. Fix. Co.
Pittsburgh: Allied Elec. Sup. Co.
Argo Lite Studios
Brisak & Green
Wally Elec. Sup. Co.
Reading: Coleman Elec. Co.
Scranton: Lewis & Reif, Inc.
Uniontown: Pioneer Electric Dist.
Wilkes Barre: Anthracite Elec.

RHODE ISLAND
Pawtucket: Major Elec. Sup. Co.
Providence: Leavitt Corson Co.

SOUTH CAROLINA
Columbia: Capitol Elec. Sup.
Noland Co.
Greenville: Sullivan Hdwe. Co.

SOUTH DAKOTA
Watertown: J. H. Larson Elec. Co.

TENNESSEE
Nashville: Nashville Elec. Sup. Co.

TEXAS
Dallas: Rogers Elec. Sup. Co.
Ft. Worth: Anderson Fixture Co.
Common Supply Co.
Houston: Gross Electric Supply
Martin Associates
Southern Electric Supply Co.
San Antonio: Southern Equip. Co.
Strauss Frank Co.

UTAH
Salt Lake City: Artistic Lighting

VIRGINIA
Arlington: Dominion Elec. Sup. Co. Inc.
Noland Co.
Lynchburg: Mid State Elec. Sup. Co., Inc.
Norfolk: Noland Co.
Roanoke: Noland Co.

WEST VIRGINIA
Huntington: West Virginia Elec. Co.
Wheeling: The Frank Co.

WISCONSIN
Appleton: Moe Northern Co.
Eau Claire: W. H. Hobbs Sup. Co.
La Crosse: W. A. Roosevelt Co.
Milwaukee: Lappin Elec. Co.
Standard Elec. Sup.

WASHINGTON
Seattle: Seattle Lighting Fix. Co

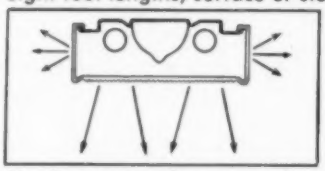
ALASKA
Anchorage: Northern Supply Co.

CANADA
Montreal: L. D. G. Products, Inc.
The Gray Elec. Co.
Union Electric Sup. Ltd.
Quebec City: La Cie Martineau Electric Co.
Toronto: Revere Elec. Dist.
Toronto Ltg. Studios

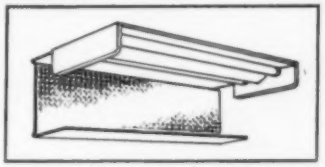
HAWAII
Honolulu: Hawaiian Light & Sup. Co.

The specification: PRISMALUX *by* LIGHTOLIER

NEW—one-piece lens-and-diffuser with low brightness bottom and luminous diffuser sides to provide glare-free illumination and minimum brightness contrast. Coupled with styling that is crisp and clean, construction that is rugged and trouble free—Prismalux is an excellent specification for stores, offices, schools and other critical lighting applications. In two, three and four light widths, four and eight foot lengths, surface or stem mounted.



The fine-textured prismatic lens floods low-brightness illumination downward. The low-brightness diffuser sides send soft light out across ceilings, reduce brightness contrasts.



For maximum rigidity, the combination lens-diffuser is supported along its full length. Safety hinges permit access from either side of lens diffuser, cannot be accidentally dislodged.

To learn more about Prismalux by Lightolier, write today for a complete brochure to Dept. IE-40.

LIGHTOLIER

Jersey City 5, New Jersey

Showrooms: New York, Chicago, Dallas, Los Angeles

Committee Personnel

(*Continued from page 48A*)

Letter Symbols and Abbreviations for Science and Engineering, Y10
Priscilla Presbrey

Drawing and Drafting Room Practice, Y14
Priscilla Presbrey

Graphic Symbols and Abbreviations for Use on Drawings, Y32
Priscilla Presbrey

Preferred Numbers, Z17
D. E. Spencer

Safety Color Code, Z53
W. H. Kahler

Colors for Industrial Apparatus Equipment, Z55
W. H. Kahler

Standardization of Optics, Z58
Priscilla Presbrey

Uniform Industrial Hygiene Standards, Z62
L. G. Parks

AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE, GOVERNING BOARD
S. K. Guth — C. L. Crouch, Alternate

ARMED SERVICES NRC VISION COMMITTEE
C. L. Crouch

INDUSTRY COMMITTEE IN CONNECTION WITH HANDBOOKS OF INTERIOR WIRING DESIGN
A. C. Bredahl — G. E. Shoemaker

INTER-SOCIETY COLOR COUNCIL
Norman Macbeth,* Chairman

R. C. Allison	H. L. Logan
C. N. Clark	J. A. Meacham
G. F. Dean	Gladys Miller
C. W. Jerome*	Paul Seagers
W. F. Little*	D. E. Spencer

*Voting delegates

NATIONAL COMMITTEE ON UNIFORM TRAFFIC LAWS AND ORDINANCES
R. P. Teele

Vehicle Lighting
R. P. Teele — V. J. Roper, Alternate

NATIONAL RESEARCH COUNCIL
Division of Engineering and Industrial Research
C. A. Douglas — E. E. Paul

Highway Research Board
(to be appointed)

National Academy of Sciences
A. F. Wakefield

National Academy of Sciences, Advisory Board on Critical Tables
W. E. Forsythe

SOCIETY OF MOTION PICTURE AND TELEVISION ENGINEERS
Herbert Kliegl

CANADIAN NATIONAL COMMITTEE OF THE INTERNATIONAL COMMISSION ON ILLUMINATION
J. W. Bateman — George Watters

U. S. NATIONAL COMMITTEE OF THE INTERNATIONAL COMMISSION ON ILLUMINATION

H. R. Blackwell	Leonard C. Mead
C. L. Crouch	E. M. Strong
Glenn A. Fry	G. J. Taylor
W. P. Lowell, Jr.	M. N. Waterman

Local Officers

(*Continued from page 52A*)

Rochester Section—Great Lakes Region
Chairman — HERBERT S. GLICK, Eastman Kodak Co., Kodak Park, Rochester, N. Y.
Secretary — GEORGE R. BUTLER, 7 Maple St., Pittsford, N. Y.

Rocky Mountain Section—Inter-Mountain Region
Chairman — GALE H. PATTERSON, General Electric Supply Co., 1429 18th St., Denver, Colo.
Secretary—FRED H. ROSENQUIST, Public Service Co. of Colorado, 900-910 15th St., Denver, Colo.

St. Louis Section—Midwestern Region
Chairman—WILLIS MANGOLD, General Electric Co., 710 N. 12th St., St. Louis, Mo.
Secretary—NORMAN L. KRAUSE, Sach's Electric Co., 5540 W. Park, St. Louis, Mo.

St. Maurice Valley Chapter—Canadian Region
Chairman—JEAN PAUL MORIN, Canadian Westinghouse Co., Ltd., 415 Craig St. W., Montreal, Que.
Secretary — GASTON J. LABROSSE, Northern Electric Co., Ltd., 2620 Notre Dame, Trois Rivieres, Que.

San Diego Section—South Pacific Coast Region
Chairman—EDWARD L. PETERSON, Edward L. Peterson Co., 709 Bank of America Bldg., San Diego, Calif.
Secretary — ALAN J. MCCUTCHEON, JR., San Diego Gas & Electric Co., 861 6th Ave., San Diego, Calif.

San Jacinto Section—Southwestern Region
Chairman—RICHARD C. JUNG, General Electric Co., 4219 Richmond Ave., Houston, Texas.
Secretary—ROBERT PUTTERMAN, R. A. Putterman Co., 4101 San Jacinto, Houston, Texas.

San Jose Chapter—South Pacific Coast Region
Chairman — GEORGE SMEDBERG, Associated Lighting Service, 780 Broadway, Redwood City, Calif.
Secretary—DALE R. JENSEN, International Business Machines, Monterey & Cottle Rd., San Jose, Calif.

Southeast Florida Section—Southeastern Region
Chairman—FRANK E. YANAROS, Florida Power & Light Co., P. O. Box 1057, Hialeah, Fla.
Secretary—BESS JONES, 95 N. E. 71st St., Miami, Fla.

Southern California Section—South Pacific Coast Region
Chairman—BENN J. HARTMANN, Flood-Lite Service, 212 Silverlake Blvd., Los Angeles, Calif.
Secretary—J. ROY JONES, Westinghouse Lamp Division, 2834 E. 46th St., Vernon, Calif.

Southern Colorado Chapter—Inter-Mountain Region
Chairman—KENNETH J. STINES, 222 S. Victoria Ave., Pueblo, Colo.
Secretary—JAMES E. PARKER, Parker & Associates, 114 W. 9th St., Pueblo, Colo.

South Plains Chapter—Southwestern Region
Chairman—RUSSELL A. TRAWICK, Texas Electric Service Co., P. O. Box 3592, Odessa, Texas.
Secretary—ROBERT BRASHER, Nunn Electric Supply Co., 2425 Texas Ave., Lubbock, Texas.

Suwannee River Chapter—Southeastern Region
Chairman—NEIL A. GLEASON, Georgia Power Co., Valdosta, Ga.
Secretary—T. J. CROUCH, 710 West Hill Ave., Valdosta, Ga.

Tar Heel Section—Southeastern Region
Chairman—T. LLEW CORDLE, J. N. Pease & Co., 2925 Independence Blvd., Charlotte, N. C.
Secretary — EVERETT D. STEVENS, Carolina Power & Light Co., Raleigh, N. C.

Tennessee Valley Section—South Central Region
Chairman—JAMES R. HARRELL, Tafel Electric & Supply Co., 401 Sixth Ave., South, Nashville, Tenn.
Secretary — WILLIAM E. JONES, Nashville Electric Service, 1214 Church St., Nashville, Tenn.

Toronto Section—Canadian Region
Chairman—R. P. LINDSAY, Canadian Line Materials, 3595 St. Clair Ave. E., Toronto 13, Ont.
Secretary—A. J. BROWN, Rest-Glow Mfg. Co. Ltd., 5600 Pare St., Montreal 9, Que.

Twin City Section—Midwestern Region
Chairman — JOHN C. NEWHOUSE, Northern States Power Co., 15 South 5th, Minneapolis, Minn.
Secretary—CHARLES DUEPNER, BMD&R, Inc., 7020 Walker St., St. Louis Park, Minneapolis, Minn.

Twin Ports Chapter—Midwestern Region
Chairman—THEODORE A. GUNDERSON, Superior Water, Light & Power Co., 1230 Tower Ave., Superior, Wis.
Secretary — ARTHUR JOHNSON, Westinghouse Electric Supply Co., 330 South 1st Ave. E., Duluth 2, Minn.

Utah Section—Inter-Mountain Region
Chairman—J. HOMER SHAW, Utah Power & Light Co., Box 899, Salt Lake City, Utah.
Secretary—HOMER S. SHERWOOD, Utah Power & Light Co., Box 899, Salt Lake City, Utah.

Vancouver Island Chapter—Pacific Northwest Region
Chairman—TOM MAWSON, Mawson Gage Ltd., 619 Chatham, Victoria, B. C.
Secretary—WALTER E. BEEK, B. C. Electric Co., Ltd., 820 Pandora Ave., Victoria, B. C.

Virginia Section—East Central Region
Chairman—WARREN G. CORNELIUS, Westinghouse Electric Supply Co., 511 E. Byrd St., Richmond, Va.
Secretary—R. W. THOMAS, Chewning & Welmer, Inc., P. O. Box 4167, Richmond, Va.

Western Michigan Section—Great Lakes Region
Chairman—LEWIS L. NURNBERGER, Consumers Power Co., 821 Hastings St., Traverse City, Mich.
Secretary — JAMES Q. MILLER, Consumers Power Co., 376 W. Western Ave., Muskegon, Mich.

Western New York Section—Great Lakes Region
Chairman—TUNIS E. BARHITE, JR., New York State Electric & Gas Corp., 115 Main St., Lockport, N. Y.
Secretary—WILLIAM J. MCCARTHY, Niagara Mohawk Power Corp., 535 Washington, Buffalo, N. Y.

Winnipeg Chapter—Canadian Region
Chairman—A. C. BURNARD, 198 Lipton St., St. James, Man.
Secretary—E. T. BATTLE, J. A. Wilson Lighting & Display, Ltd., 626 Campbell St., Winnipeg, Man.

Yankee Chapter—Northeastern Region
Chairman — FRANK P. HAYDEN, 1312 Page Blvd., Springfield, Mass.
Secretary — ALBERT LACAS, Western Massachusetts Electric Co., 48 Eagle St., Pittsfield, Mass.

Yosemite Chapter—South Pacific Coast Region
Chairman—DONALD E. FISHER, Pacific Gas & Electric Co., P. O. Box 180, Selma, Calif.
Secretary—EDWARD F. BOWEN, City of Fresno, Fresno City Hall, 2326 Fresno St., Fresno, Calif.

ALKCO SPACE-LITES are incredibly tough, warp-proof, colorfast...deliver 60% more light than other fixtures of the same wattage

stay light years ahead with

The startling simplicity of ALKCO Space-Lites actually cut installation costs by ⅓... can be quickly and profitably installed in *any* ceiling—tile, plaster or dry-wall. The diffuser requires no frame and that means no trim time. With no exposed metal to rust or corrode, Space-Lites are almost ageless. And because there is no trim frame, an additional glow of light is transmitted all around the perimeter.

The handsomely designed diffuser is made of virtually unbreakable, translucent ALKCOrylic. ALKCOrylic is incredibly tough, probably the only organic material that will withstand incandescent heat without warping or discoloring. This remarkably versatile material can be used in many installations where glass might be easily damaged. Because the diffuser is larger and formed deeper, it delivers 60% more light than flat diffusers that incorporate frames. It snaps in or out of the fixture under normal finger pressure and the bulb can be changed in seconds.

Get the full, profitable facts on ALKCO Space-Lites and other exciting, new lighting ideas by ALKCO—among them "Little Inch," a fluorescent under-cabinet light only ⅞" deep. Send today for free Catalog.

ALKCO MANUFACTURING COMPANY · 4224 No. Lincoln Ave. · Chicago 18, Illinois

engineered versatility—custom and stock lighting equipment for commercial, industrial and residential installations.

ALKCO

EVERY
PERSON
HAVING
RESPONSIBILITY
FOR
SPECIFYING
SCHOOL
LIGHTING
SHOULD
HAVE
THIS
BOOK

FREE!*

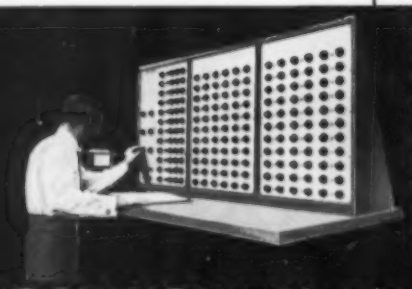
The A-B-*See* of Modern School Lighting

24 pages of vital information involved in classroom lighting and lighting other school areas. Explains how much light students require for easiest study. Illustrates with photos and text the effects of glare and brightness. Gives recommended reflectance values for proper seeing conditions within classrooms.

* PRICE TO GENERAL PUBLIC $1.00

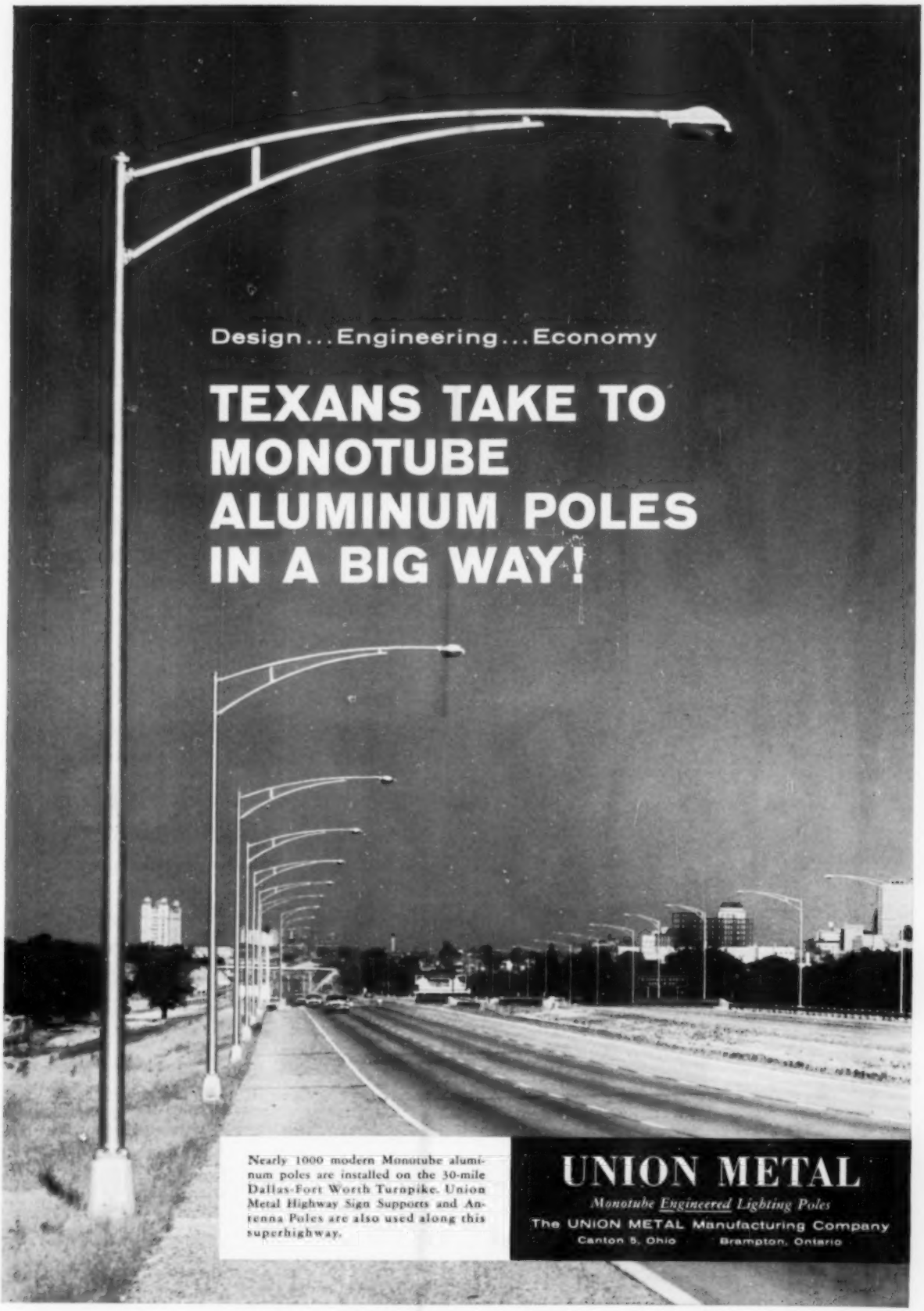
A comparison chart of different types of lighting fixtures is included in the Classroom Lighting section. Many types of fixtures commonly used for areas other than classrooms such as libraries, labs, shops, auditoriums, gyms, are illustrated and recommendations for use given at the end of Section Two.

Write for your copy today.

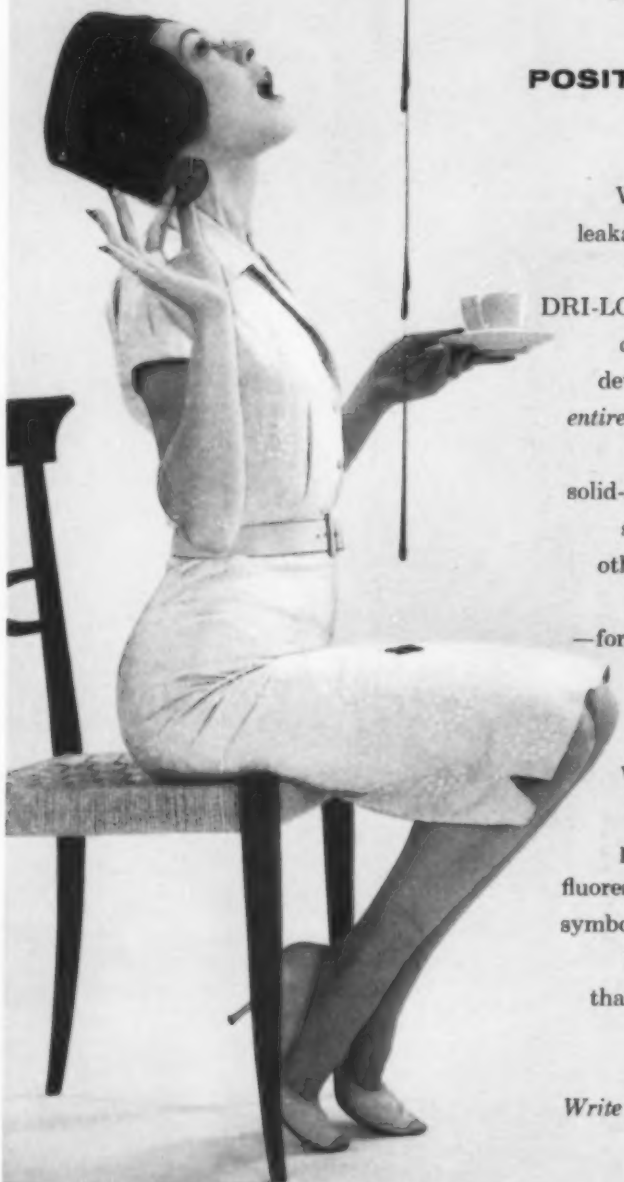


Many problems discussed in this book were solved by Smoot-Holman's advance design analogue computer. This new computer, the only one of its type ever built for commercial use, solves problems of fixture design, as well as many other problems in the field of lighting.

SMOOT-HOLMAN COMPANY · *Inglewood* · *California*


Design...Engineering...Economy
TEXANS TAKE TO MONOTUBE ALUMINUM POLES IN A BIG WAY!
Nearly 1000 modern Monotube aluminum poles are installed on the 30-mile Dallas-Fort Worth Turnpike. Union Metal Highway Sign Supports and Antenna Poles are also used along this superhighway.
UNION METAL
Monotube Engineered Lighting Poles
The UNION METAL Manufacturing Company
Canton 5, Ohio
Brampton, Ontario

THIS... *need never happen again!*



NEW *SOLID-FILL* JEFFERSON DRI-LOK BALLAST GIVES POSITIVE PROTECTION AGAINST COMPOUND DRIP!

Why chance the danger of messy compound leakage? Jefferson has solved this unpredictable problem with an entirely new ballast—the DRI-LOK. Instead of being filled with conventional compound, the DRI-LOK contains a newly developed thermo-setting material. It fills the *entire* case and *permanently* bonds case, core and coil into one solid, voidless unit. This dry, solid-fill material is so chemically and physically stable, it cannot combine or react with any other material in the ballast. It cannot soften or liquefy under any operation conditions —for the life of the ballast. Only the DRI-LOK ballast offers this positive protection.

It's NEW and It's BLUE

We've enameled the new DRI-LOK ballast *blue* so you'll instantly recognize the finest performing ballast since the introduction of fluorescent lighting! Jefferson *Blue* has long been symbolic of excellence. The new, blue DRI-LOK ballast is the latest in many advancements that have strengthened the Jefferson tradition of sound research, excellent design and quality manufacture.

Write today for complete details and specifications.

Jefferson DRI-LOK

New Blue FLUORESCENT BALLASTS

JEFFERSON ELECTRIC COMPANY • BELLWOOD, ILLINOIS

"... required reading for all architects, designers and illuminating engineers."*

Now — from leading technologists of the world famous Philips' Eindhoven establishment in Holland — **the newest definitive work on**

FLUORESCENT LAMPS AND LIGHTING

Edited by W. Elenbaas

Profusely illustrated, this indispensable reference (346 pages) discusses the latest developments in fluorescent lighting techniques and lamp constructional details. Much of the material has never appeared in book form.

Here — for electrical engineers and specialists who want to know more about cost factors, installation and maintenance — are comprehensive treatments of:

- The physics of light.
- Fixture design problems.
- Special application circuits for dimming and flashing.
- The chemistry and physical concepts of phosphors.
- The generation of light by fluorescence.
- Circuits and their features.
- The problems of color rendering.
- Psychological factors.
- The effects of ballast design.
- The paramaters of fluorescent lamp design.

FLUORESCENT LAMPS AND LIGHTING explains the development of "de luxe" colors . . . the energy balance of the fluorescent lamp . . . the basic requirements of lamp components. It offers reliable data on lamp efficiency. And it contains the most up-to-date information available on the use of fluorescent lighting in:

____Offices	____Drafting offices	____Hotels
____Classrooms	____Restaurants	____Store windows
____Television studios	____Agricultural installations	____Ships
____Homes	____Theatres	____High-level installations
____Factories	____Houses of worship	____Art studios
____Museums	____Streets	____Bus depots
____Stores	____Hospitals	____Cafeterias
____Railway stations	____Concert halls	____Trains
____Automobile showrooms	____Indoor arenas	

CONTENTS

Luminescence, Fluorescence and Phosphorescence.
Luminescent Substances
Color of the Light Emitted by Fluorescent Lamps: Color Rendition.
Gaseous Discharges.
Lamp Construction.
Factors Affecting the Efficiency.
Stabilization of the Discharge.
Lamp Types and Circuits.
Ballasts for A.C. Operation.
Fluorescent Lamp Fittings.
Progress in Lighting.
Application of Fluorescent Lamps.
APPENDIX I: Fluorescent Lamps with a High Luminous Output Per Unit Length.
APPENDIX II: Transistor Circuits.
1. Introduction.
2. Principle of the Transistor Converter.
3. Constructional Details of the D.C.-A.C. Converters.
4. Applications of D.C.-A.C. Converters.
5. D.C.-A.C. Converters.
INDEX

* "When we realize the importance of lighting in architecture and design, we realize the necessity of knowing all we can about light. And this means a sound knowledge of light sources. The fluorescent source in particular seems to show up the lack of such knowledge. On the one hand, there is too much paraphenalia wasted on fluorescent lamps, trying to get them to do what they can't do, by their very nature. On the other hand, there is too little application of fluorescent principles in lighting designs, so that the lamps be allowed to do what they do best. With a book like **Fluorescent Lamps and Lighting** now on hand, those of us who work with light have no excuse for not knowing better. It's an invaluable book: required reading for all architects, designers and illuminating engineers."

/s/Abe H. Feder
LIGHTING BY FEDER

The Macmillan Company, Dept. IE-1
60 Fifth Avenue, New York 11, N. Y.

Please send me:

..... copies of FLUORESCENT LAMPS AND LIGHTING @ $11.00 each

☐ Bill me ☐ Bill my firm ☐ Payment enclosed*

I understand that I may return the book(s) within 10 days without obligation.

NAME .....

FIRM .....

ADDRESS .....

*SAVE POSTAGE: If payment accompanies order, we pay the postage. Same return privilege; refund guaranteed.

FREE TEN-DAY TRIAL — NO OBLIGATION

COMBINE

light and sound

CONTROL IN ONE MEDIUM WITH

CONTREX SOUNDSHEET

An interesting installation, using Contrex Soundsheet, in the offices of Lockheed Aircraft Corporation's new plant, Marietta, Ga.

Soundsheet Translucent Acoustical Element provides balanced sound absorption plus superior light diffusion in **one** medium. The use of Soundsheet shielding, in a ceiling system of your choice, offers new economies and interesting, fresh architectural interior concepts. Available translucent or opaque in flat or corrugated sheets, or in 2′ x 2′ tension or edge-framed modular panels.

- Easy to install
- Washable
- Won't crack, craze or break
- Opaque or translucent
- UL, Factory Mutual and FIA listed

CONTREX

Developed for Contrex by Bolt Beranek and Newman, Inc.

Contrex Company, Chelsea 50, Mass.

Gentlemen: Please send me your latest catalog, describing new applications for versatile Soundsheet, Acrilume Light Diffusers and Cushionall Panels.

Name_____

Company_____

Address_____

City_____ State_____

IE-4

Employment Opportunities

LIGHTING SALES ENGINEER AVAILABLE

Excellent background in the Commercial and Industrial lighting industry. Thoroughly experienced (17 years) in illuminating engineering and sales to specifiers, contractors, industrials and wholesalers. Capable of writing specifications with architects and engineers. All phases of the industry—fluorescent, incandescent, floodlighting, and ceilings. All experience in the Chicago trade area. Salary or salary and commission. Please write Box 441, Publications Office, Illuminating Engineering Society, 1860 Broadway, New York 23, N. Y.

ENGINEERS

For manufacturer of electrical products expanding Engineering, Development, and Research facilities.

(a) Recent graduates with EE degree. Supervisory potential desired.
(b) Optical designer—BS-EE or Physicist, experienced.
(c) Photometrist—BS-EE or Physicist, experienced.

Salary commensurate with ability and experience. Excellent supplementary benefits and retirement plan with a secure future. Location Central New York State. Address Box 442, Publications Office, Illuminating Engineering Society, 1860 Broadway, New York 23, N. Y.

WANTED — MANUFACTUREE'S REPRESENTATIVES

Pioneers of outstanding reputation in the Fluorescent Lighting business, expanding coverage, have openings for exclusive agency representation in many territories. Lines include Commercial; Industrial; Institutional; Schools; "Protected" lighting for subways, tunnels, underground garages, etc.; Vaportight Units for standard and special applications; and various types of Fluorescent Custom Lighting. Our name appears on approved lists of Ford, Chrysler, G.M. and their subsidiaries, indicating product acceptability. Volume installations for these companies, and other large firms and municipalities throughout the country in our background prove our know-how and performance. Architectural specification grade quality approved by leading Architects and Engineers in areas now served. Sales policy through wholesale Electrical Jobbers and Distributors only. Flexibility and Cooperation to our representatives is without limit. Correspondence will be held in confidence. Advise territory covered, sources called upon, lines now handled, industry background, etc. Send to—

J. Reznik
Tri Part Mfg. Co.
925 Cherry St.
Detroit 1, Mich.

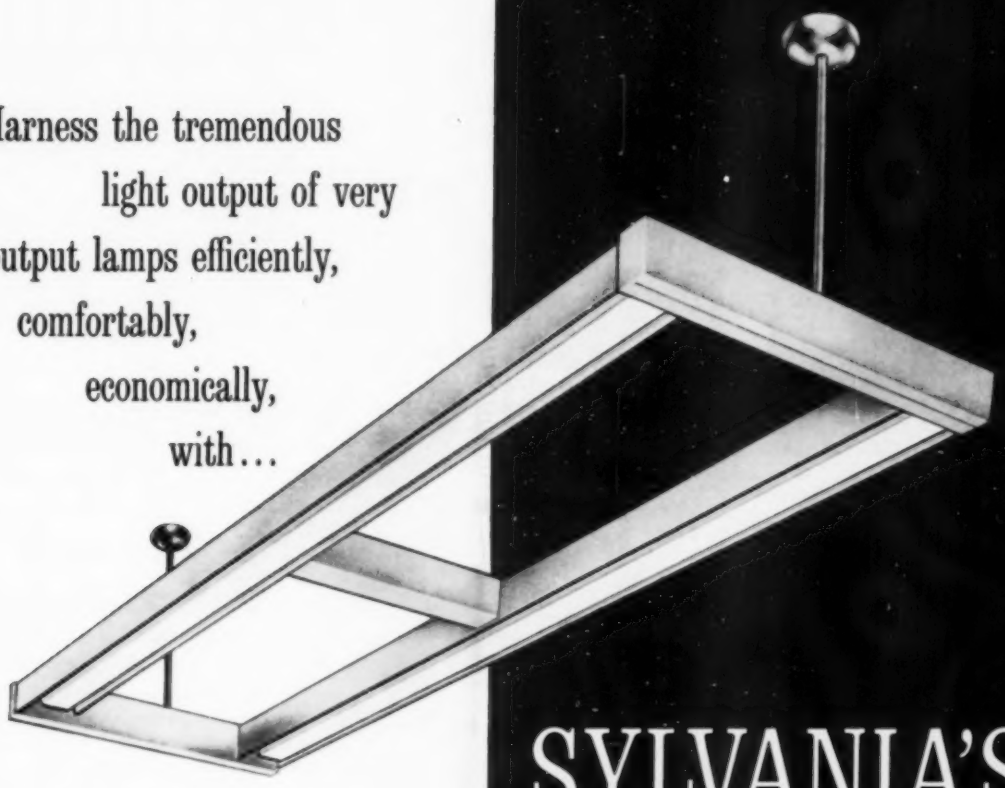
WANTED
LIGHTING FIXTURE SALESMAN

Experienced salesman wanted by well known manufacturer of specification commercial and industrial fluorescent fixtures. Architect and engineering contracts required. Territory: New York and New Jersey. Fine opportunity with excellent future. All resumes received in strict confidence. Address Box 443, Publications Office, Illuminating Engineering Society, 1860 Broadway, New York 23, N. Y.

APPLICATION ENGINEER

Graduate Electrical Engineer with construction, utility and lighting system design experience wants engineering or management position in New England. Address Box 437, Publications Office, Illuminating Engineering Society, 1860 Broadway, New York 23, N. Y.

Harness the tremendous
light output of very
high output lamps efficiently,
comfortably,
economically,
with...



SYLVANIA'S HQ Series

(High Quality)

Now you can utilize the extremely high lumen output of 800 ma. and 1500 ma. lamps in schools, offices, drafting rooms and other commercial applications without sacrificing eye comfort for adequate footcandles.

Sylvania's HQ Series provides the long-recognized quality of indirect lighting. It eliminates the brightness contrasts, direct glare and reflected glare found in many lighting installations.

The use of a slim channel just large enough to hold a standard-diameter fluorescent lamp and its shielding . . . with ballasts hidden in the supporting members . . . results in a graceful, practical fixture that provides an excellent balance of quality, appearance, efficiency and easy maintenance.

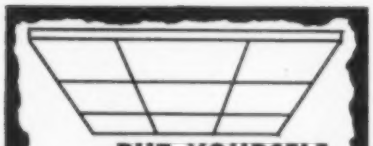
When the combination of these features—together with high illumination—are important factors in your lighting plans, be sure to check the features of Sylvania's HQ Series. Write today for full information.

SYLVANIA LIGHTING PRODUCTS
A Division of SYLVANIA ELECTRIC PRODUCTS INC.
One 48th Street, Wheeling, West Virginia

GO MODERN WITH LIGHTING BY **SYLVANIA**

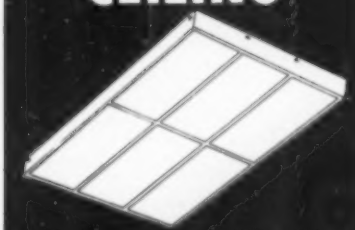
Subsidiary of GENERAL TELEPHONE & ELECTRONICS

FLUORESCENT LIGHTING FIXTURES AND SYSTEMS • BEST FIXTURE VALUE IN EVERY PRICE RANGE



PUT YOURSELF IN A *BETTER LIGHT* WITH metco *Lighting*

Power LITE FLOATING CEILING



Economical . . . Compact

HIGH LEVEL

Comfortable Illumination

Power-LITE is a pendant type fixture (C.I.E. general diffuse classification) modular in design. It provides high intensity, glare-free, direct-indirect illumination in a large area. Utilizing new high lumen output 15,000 MA lamps, it provides up to 200 to 450 foot-candles of illumination at working levels, comfortably shielded by 45°-45° aluminum or plastic louvers. Power-LITE is a completely satisfactory alternative to suspended ceiling construction that minimizes lighting contrasts by distributing its light on ceiling and walls as well as down on the working area.

Write today for full details and catalog sheet.

SOLD ONLY THROUGH QUALIFIED ELECTRICAL DISTRIBUTORS

METALCRAFT
PRODUCTS CO., INC.
6225 State Road, Phila. 35, Pa.

(Continued from page 32A)

HAMILTON, ONTARIO, CHAPTER

Member:

*Morgan, J. F., J. F. Morgan Associates, Stoney Creek, Ont.

INDIANA SECTION

Associate Members:

Meador, D. E., Indianapolis Power & Light Co., Indianapolis, Ind.

Vargo, J. A., Line Material Industries, Indianapolis, Ind.

IOWA SECTION

Member:

*Severance, J. D., Iowa Illinois Gas & Electric Co., Rock Island, Ill.

Associate Member:

Johnson, J. D., Crescent Electric Supply Co., Des Moines, Iowa.

MARITIME CHAPTER

Associate Member:

Ostler, Kenneth, A. P. M., Ltd., Moncton, N. B.

MARYLAND SECTION

Associate Member:

Doarnberger, J. R., United States Fidelity & Guaranty Co., Baltimore, Md.

MIAMI VALLEY SECTION

Members:

*Burnham, S. L., General Electric Co., Dayton, Ohio.

*Burrall, Harrison, Sylvania Lighting Products, Dayton, Ohio.

*Roof, G. L., Prescolite Mfg. Corp., Dayton, Ohio.

MICHIGAN SECTION

Member:

*Walts, D. L., Standard Electric Co., Saginaw, Mich.

MILWAUKEE SECTION

Member:

*Heil, E. J., Westinghouse Electric Corp., Milwaukee, Wis.

Associate Members:

Barber, G. B., Line Material Industries, S. Milwaukee, Wis.

Fieldstad, Donald, Jr., Line Material Industries, S. Milwaukee, Wis.

Munagian, John, Line Material Industries, S. Milwaukee, Wis.

MISSISSIPPI CHAPTER

Member:

*Richardson, E. K., Mississippi Power Co., Meridian, Miss.

MONTREAL SECTION

Associate Members:

Bonin, M. L., J. A. Wilson Lighting & Display Ltd., Montreal, Que.

Walker, Keith, J. A. Wilson Lighting & Display Ltd., Montreal, Que.

NEW ENGLAND SECTION

Members:

Cohen, Sheppard, Sylvania Lighting Products, Ipswich, Mass.

*Whitaker, C. E., The Narragansett Electric Co., Providence, R. I.

Wiederhold, P. R., Sylvania Electric Products, Inc., Ipswich, Mass.

Associate Members:

Denio, A. A., Haverhill Trade School, Haverhill, Mass.

Monte, Ernest, Litecontrol Corp., Watertown, Mass.

Wilson, S. L., Central Maine Power Co., Rockland, Me.

NEW JERSEY SECTION

Members:

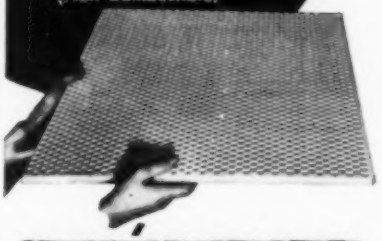
*Burck, Seymour, Sylvania Electric Products, Inc., Teterboro, N. J.

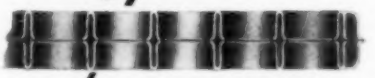
*Masterson, R. A., Public Service Electric & Gas Co., Plainfield, N. J.

(Continued on page 63A)

CIRCLGRID LOUVERS

Listed UL 20
(Non Combustible)





Enlarged cross section view

Nominal Sizes—2′ x 2′ x ½″
" " 2′ x 4′ x ½″
Translucencies—300-150-75 FC

With OUTSTANDING BRIGHTNESS CONTROL

Circlgrids are thermo-formed from 2 sheets of vinyl and fused electronically to a center vinyl membrane for structural strength and rigidity—yet weigh only 3½ oz./sq. ft. Many leading lighting equipment manufacturers are licensed to sell and distribute Circlgrid.

CIRCLGRID ADVANTAGES

- Listed UL 20 (non-combustible)
- Circular openings assure non-glare illumination and promote free air circulation
- Safely installed under sprinklers
- Weight–3½ oz./sq. ft.
- Cut-off 45°-45°
- Can be contoured to fit irregular areas
- Outstanding brightness control

Write for sample and technical data.

circ-vac plastics

BOX 655-J • ERIE, PA.

Illuminating Engineers and Specialists in Vacuum Forming and Electronic Welding

(Continued from page 62A)

Associate Members:

Frandsen, D. V., Sola Electric Co., Little Ferry, N. J.

Sahlman, J. A., Public Service Electric & Gas Co., Newark, N. J.

NEW MEXICO CHAPTER

Associate Member:

Inglee, P. R., General Electric Co., Denver, Colo.

NEW YORK SECTION

Members:

*Blitzer, W. F., Lightolier, Inc., Jersey City, N. J.

*Gelman, Marvin, Lighting Services, Inc., New York, N. Y.

*Hartley, H. S., General Electric Co., New York, N. Y.

*Liberman, Milton, Miroflector Co., Inc., Inwood, N. Y.

*MacLeod, H. G., Graybar Electric Co., Inc., Long Island City, N. J.

*Mayer, H. C., General Electric Co., New York, N. Y.

Mumford, H. W. Jr., Western Electric Co., Inc., New York, N. Y.

*Oster, Joseph, Globe Lighting Products, Inc., Brooklyn, N. Y.

*Wernert, N. E., Consolidated Edison Co., New York, N. Y.

Associate Member:

Kahn, Myron, Polarized Lighting Int'l., Inc., Whitestone, N. Y.

NON-SECTION

Associate Members:

Hibbitt, T. A., New Era Lighting Industries, Durban, Natal, South Africa.

Waimann, Joseph, Luxram Electric Ltd., London, England

NORTH TEXAS SECTION

Member:

*McFarland, J. W., General Electric Co., Dallas, Texas.

OHIO VALLEY SECTION

Members:

*Newell, J. K. Jr., General Electric Co., Louisville, Ky.

*Shaw, R. F., The Johnson Electric Supply Co., Cincinnati, Ohio.

OIL CAPITAL SECTION

Member:

*Seay, J. R., Seay Electric Co., Tulsa, Okla.

OREGON SECTION

Member:

*Pellicano, Joseph, 1226 S. W. Hume St., Portland, Ore.

OTTAWA SECTION

Member:

McGarry, W. F., J. L. Richards & Associates, Ltd., Ottawa, Ont.

PHILADELPHIA SECTION

Associate Member:

McBride, R. W., Philadelphia Electric Co., Philadelphia, Pa.

Weiss, L. J., Duro-Test Corporation, Philadelphia, Pa.

PITTSBURGH SECTION

Associate Members:

Friedman, Jack, Lustra Corp. of America, Pittsburgh, Pa.

Huot, F. S., Kopp Glass, Inc., Pittsburgh Pa.

ROCHESTER SECTION

Associate Member:

Englert, G. M., McFarlin Electric Co., Rochester, N. Y.

ST. LOUIS SECTION

Members:

*Penn, L. W., Jr., Sverdrup & Parcel, St. Louis, Mo.

(Continued on page 64A)

NEW BULLET BEAUTY

FOR OUTDOOR DUTY!

Don't let the styling of STONCO's new "Award Series" fool you. These are **outdoor** bullets. Solid cast aluminum. Completely weatherproof. "Air-conditioned" for cooler, cleaner operation. The only truly decorative floodlights designed specifically for any outdoor application.

1 Epoxy-cured finishes stay factory-fresh through severest weather. Resist salt-spray, corrosives.

2 Degree-marked pre-aiming quadrant.

3 Deep-gripping serrated teeth for focus lock-in.

4 Full-circle vented ribs (pat. pend.) — pull a moving, cooling air-stream up through the fixture and out.

5 Big internal heat-dissipating fins.

6 STONCO "Cushion-Seal" — high-temperature live silicone-rubber weatherseal. Protects in any fixture position, even face-up.

7 Plenty of grip-space between lamp and shield.

8 Lifetime cast aluminum — with that solid heft indoor units just don't have.

A COMPLETE LINE FOR 75W-300W REFLECTOR LAMPS Single or cluster fixtures in 3 distinctive styles, wide range of finishes. For ceilings, walls, under eaves . . . all exteriors requiring a high-degree of architectural and color fidelity.

- The Award Series is now on display at your STONCO distributor. Look for it.
- Write today for Award Series catalog: Section A-34.
- See Sweet's Architectural file: 33a/ST.

STONCO *Award Series*

CLUSTER LIGHTS
POWER BEAMS
VAPORTIGHT
BOXES and FITTINGS
EMERGENCY PORTABLES

STONCO ELECTRIC PRODUCTS CO. • KENILWORTH, NEW JERSEY

48-1000 line
the high ceiling
GLARE-FREE
recessed downlights

For AUDITORIUMS, LOBBIES, BANKS, SCHOOLS, HOSPITALS, THEATRES, ARENAS, AIRPORT or RAILROAD TERMINAL BUILDINGS and other high ceiling applications where comfortable light with glazeless source is required.

48-1000 line by mcPhilben is an optically perfected low brightness, ventilated recessed downlight . . . Cast aluminum radiator with cooling fins insures low maintenance cost and long lamplife with minimum reflector dirt accumulation . . . Precision ellipsoidal reflector is either Alzac aluminum or "golden" Alzac for soft, warmer levels of light . . . Only ONE inch width of exposed flange guarantees absolute blending with plaster or acoustical ceiling . . . Adjustable "Deflector" for uniform wall illumination floor to ceiling . . . Prefabricated collars for easy installation in sloped ceilings . . . Ask your mcPhilben representative for complete specification data or write to mcPhilben.

48-1000 line units lighting the Auditorium of Bronx High School of Science, Bronx, N. Y.

mc Philben
LIGHTING
1329 Willoughby Ave., Brooklyn 37, N. Y.
In Canada: mcPhilben division of Wakefield Lighting Ltd., London, Ontario

Representatives in all principal cities. Specification Data Sheet D15 on request

33a Mc

Sweet's

(*Continued from page* 63A)

Rich, L. B., Albert Rich Co., Clayton, Mo.

Associate Members:

Bartel, E. G., Day-Brite Lighting Inc., St. Louis, Mo.
Buss, Richard A., Day-Brite Lighting, Inc., St. Louis, Mo.
Gilbert, F. C., Day-Brite Lighting, Inc., St. Louis, Mo.
Quinn, J. E., Day-Brite Lighting, Inc., St. Louis, Mo.
Ryan, J. F., Day-Brite Lighting, Inc., St. Louis, Mo.
Zimmerman, Elliott, Day-Brite Lighting, Inc., St. Louis, Mo.

San Diego Section

Member:

*Kendall, F. I., Pacific Telephone & Telegraph Co., San Diego, Calif.

Southeast Florida Section

Members:

Nash, J. K., Florida Power & Light Co., W. Palm Beach, Fla.
Tannhauser, W. H., Tannhauser Designs, Inc., Miami, Fla.

Associate Members:

Anderson, A. F., Atlantic Electric, Pompano, Pompano Beach, Fla.
Bailey, C. E., Philpott, Ross & Saarinen, Engineers, Ft. Lauderdale, Fla.
Bergovoy, Jack, Atlantic Electric, Inc., Ft. Lauderdale, Fla.
Caravacci, H. A., Atlas Electric Supplies, Ft. Lauderdale, Fla.
Eaker, E. Y., Florida Power & Light Co., Ft. Lauderdale, Fla.
Flewellen, W. B. Jr., Florida Power & Light Co., Ft. Lauderdale, Fla.
Furst, W. A., 2632 N. E. 24th St., Ft. Lauderdale, Fla.
Guffy, L. E., Lohman Electric Co., Ft. Lauderdale, Fla.
McEachern, M. D., General Electric Supply Co., Ft. Lauderdale, Fla.
Puia, C. Y., Qualmann & Puia, Ft. Lauderdale, Fla.
Qualmann, W. C., Qualmann & Puia, Ft. Lauderdale, Fla.
Ritter, C. L., Atlas Wholesale Electrical Supplies, Ft. Lauderdale, Fla.
Sapp, C. T., McDonald Distributor of Florida, Ft. Lauderdale, Fla.
Sloan, A. S., Gamble, Pownall & Gilroy, Ft. Lauderdale, Fla.
Summerall, Lester, Graybar Electric Co., Inc., Ft. Lauderdale, Fla.
Turpin, W. B., Florida Power & Light Co., Hollywood, Fla.
Tutten, B. E., Tutten Electric Co., Inc., Ft. Lauderdale, Fla.
Vincent, K., E., General Electric Co., Miami, Fla.

Southern California Section

Members:

*Grossman, M. B., Baxton Associates, Sun Valley, Calif.
*Wirth, S. R., Wirth Engineering Co., Culver City, Calif.

Associate Members:

Brunner, C. J., Sunbeam Lighting, Los Angeles, Calif.
Chapouris, John, Clayton Mfg. Co., El Monte, Calif.

South Plains Chapter

Associate Member:

Toland, Robert, Southwestern Electric Supply, Lubbock, Texas.

Tar Heel Section

Members:

Phillips, C. H., Watson Engineers, Greensboro, N. C.
West, F. E. Jr., Duke Power Co., Charlotte, N. C.

(*Continued on page* 65A)

NEW! Nightingale Wall Light

Gracefully Complements the Finest Furnishings
HOSPITALS DORMITORIES HOTELS MOTELS

Universally adjustable reading and examining light . . . separate indirect light for general illumination . . . subdued night light . . . convenient plug-in receptacle.

Double-walled reflector is thoroughly ventilated . . . can't burn fingers. Its unique, one-piece reverse-spun construction provides added strength . . . eliminates seams that may loosen or break apart.

Model No. 617

Adjustable FIXTURE CO. Lighting

106-108 E. Mason St.
Milwaukee 2, Wis.

(*Continued from page* 64A)

TENNESSEE VALLEY SECTION

Member:

*Phillips, T. N., Nashville Electric Service, Nashville, Tenn.

TORONTO SECTION

Member:

Groves, Ross, Powerlite Devices, Ltd., Toronto, Ont.

Associate Members:

Burge, A. R., Hugh C. Maclean Publications Ltd., Don Mills, Ont.
Morrison, I. Y., Powerlite Devices Ltd., Toronto, Ont.

TWIN CITY SECTION

Members:

*Ellison, G. P., Ericksen Ellison & Associates, Inc., St. Paul, Minn.
*Graf, R. J., Northern States Power Co., Minneapolis, Minn.
*Jacobson, H. B., Northern States Power Co., Minneapolis, Minn.
*Moore, G. B., Gausman & Moore, Inc., St. Paul, Minn.
Schnarr, R. A., City of St. Paul, St. Paul, Minn.
*Woodward, O. R., Terminal Electric Corp., Minneapolis, Minn.
*Zeeb, M. W., Northern States Power Co., Minneapolis, Minn.

Associate Members:

Cohen, A. D., Chicago Hardware & Paint Co., Minneapolis, Minn.
Larson, H. G., T. E. Roche, Consulting Engineer, Minneapolis, Minn.
McNamee, P. H., General Electric Supply Co., St. Paul, Minn.
Nelson, H. G., Northern States Power Co., Sioux Falls, Ia.
Peterson, G. A., T. E. Roche, Consulting Engineer, Minneapolis, Minn.

TWIN PORTS CHAPTER

Associate Members:

Adams, W. G., Arrowhead Electric, Inc., Duluth, Minn.
Erickson, E. G., Erickson Electric Co., Duluth, Minn.
Mangan, Norman, Electric Construction Co., Duluth, Minn.
Simonson, D. J., Minnesota Power & Light Co., Duluth, Minn.

UTAH SECTION

Associate Member:

Buller, E. A., Buller Electric Co., Provo, Utah.

VIRGINIA SECTION

Members:

*Austin, O. A. Jr., Austin Electric Co., Norfolk, Va.
*Mitchell, A. R. Jr., Crouse-Hinds Co., Richmond, Va.

WESTERN MICHIGAN SECTION

Member:

*Graham, R. C., 2627 Hall S. E., Grand Rapids, Mich.

WESTERN NEW YORK SECTION

Members:

*Ackendorf, W. P., Niagara Mohawk Power Corp., Fredonia, N. Y.
*Herget, R. R., Robertson Electric Co., Inc., Buffalo, N. Y.

WINNIPEG CHAPTER

Member:

*Babletek, J. L., Waisman-Ross & Associates, Winnipeg, Man.

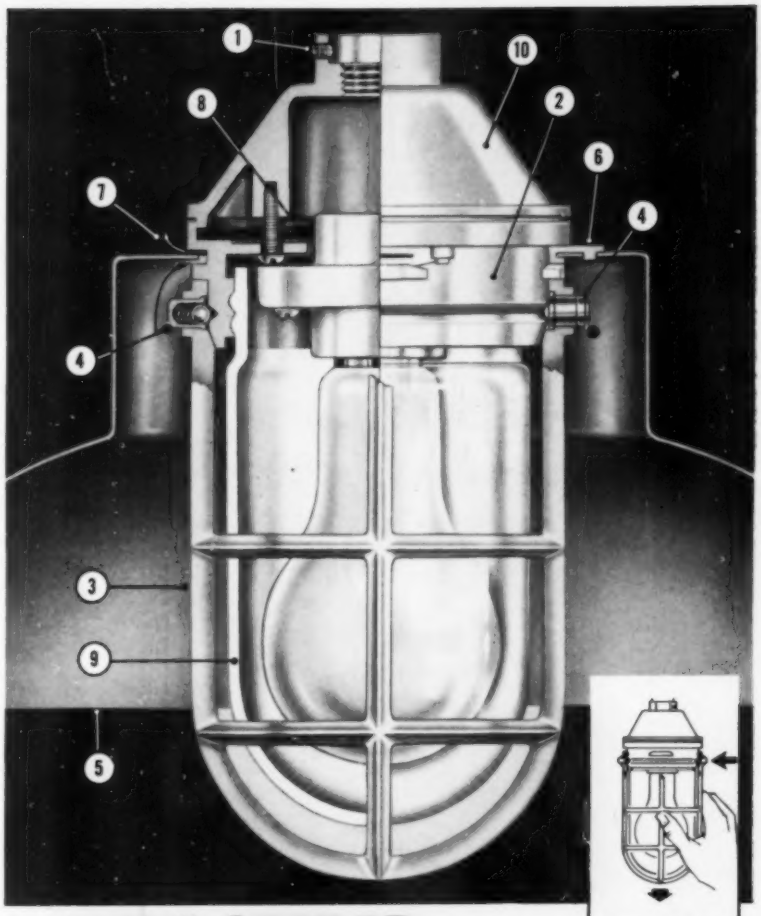
YANKEE CHAPTER

Member:

Wood, W. E., McClintock & Craig, Springfield, Mass.

Associate Members:

Gomes, Abel, Abel Gomes, Electrical Contractor, Chicopee, Mass.
La Duke, D. P., Western Massachusetts Electric Co., Pittsfield, Mass.

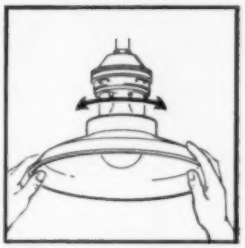


Guards removable without tools.

NEW STEBER

ALUMINUM VAPORTITE INDUSTRIAL LIGHTING FIXTURES

1. Pendent mounting, die-cast aluminum with lock screw.
2. Universal Fixture Body, die-cast aluminum—takes pendent, ceiling and wall bracket adaptors.
3. Protective guard, die-cast aluminum.
4. Stainless Steel Ball Detents—permit attachment and removal of guard without aid of tools.
5. White Porcelain Enameled Reflector—Standard Dome, Shallow, Deep Bowl or 30° Angle.
6. Nylon shoes—allow reflector to be attached to fixture body by 45° turn—no tools needed.
7. Reflector Ventilating gaps provide chimney action cooling and cleaning.
8. Gasketed construction isolates wiring compartment.
9. Heat-resistant glass globe, clear or choice of four colors.
10. All aluminum components coated with graytone baked ULTRANAMEL to protect against chemical fumes, caustic, etc.



Reflectors, removable by a 45° turn without tools for convenient cleaning.

Specification Bulletin No. 1099-60 available on request.

New, Complete Steber line is years ahead in design, engineering and construction. Steber units *have* the features you want. Their functional design gives you the complete easy adaptability you need. Steber Fixtures are U/L and CSA approved and meet Navy, Corps of Engineers and General Service Administration specifications.

Lighting Units **STEBER** *for Every Need*

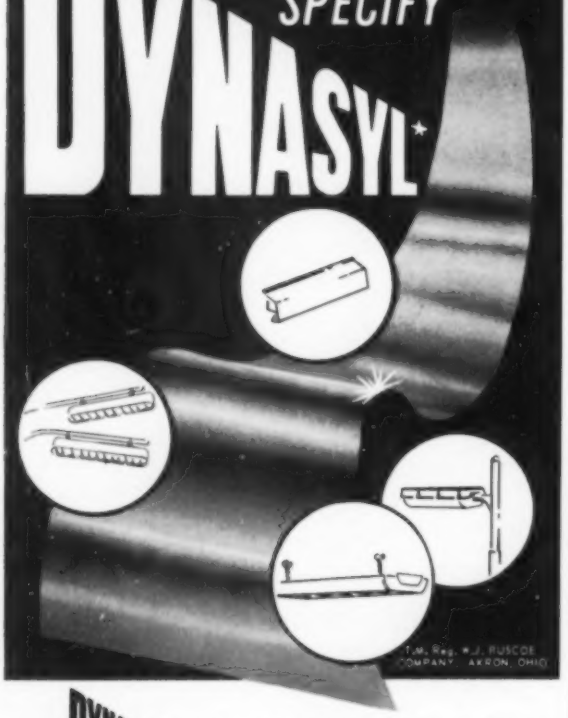
STEBER, DEPT. 66-D, BROADVIEW, ILLINOIS

Steber of California, 242 S. Anderson St., Los Angeles 33, Cal.

TO REDUCE LUMINAIRE MAINTENANCE

SPECIFY

DYNASYL*



DYNASYL Specular Aluminum Reflector Sheet (Pat. Applied For) is corrosion resistant, stays bright even in areas with heavy salt concentration. Ideal in industrial areas, DYNASYL retains original reflectivity with an occasional wipe of a damp cloth.

DYNASYL is outstanding for use in lighting equipment design and manufacturing. It can be punched, crimped or drilled without damage to the finish. Ready for use without buffing or anodizing, DYNASYL helps keep costs low. Available in any gauge, temper or alloy.

FOR FREE DESCRIPTIVE BOOKLET AND SAMPLE, WRITE: Dept. I-4

W. J. RUSCOE COMPANY
LAMINATING DIVISION
475-485 Kenmore Blvd. • Akron 1, Ohio

DIRECT-THE-LITE

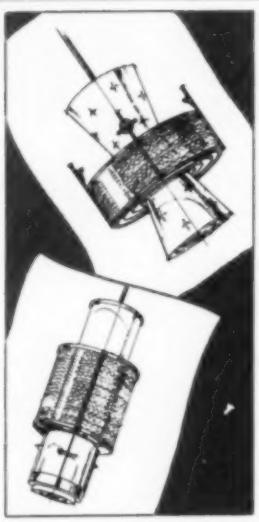
SEMI-CONCEALED, ADJUSTABLE FLOODLIGHTING or SPOTLIGHTING

Triangular housing makes this the perfect unit for unobtrusive, neatly integrated spot- or flood-lighting. Ideal for use in stores, churches, building lobbies, theaters, displays, etc. Can be easily mounted either horizontally or vertically.

Available in 1, 2 or 3 lamp units (with each lamp in adjustable Gimbal ring) in two sizes: for 150 W or 300 W PAR-type lamps. Optional color filters for special lighting effects.

Write for bulletin on "Direct-the-Lite"

NL Corporation
2490 East 22nd St.
Cleveland 15, Ohio



First in Design for church lighting

Eye-Easy lighting is often copied, never duplicated. It combines original designs with quality craftsmanship for a tailor-made look at production prices. Write for modern or traditional catalog now!

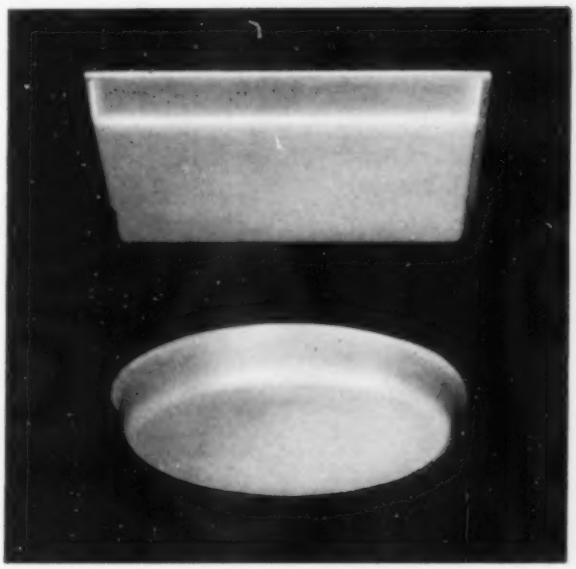
R.A. MANNING CO. INC.
Eye-Easy
SHEBOYGAN, WIS.
In Canada "Red Comet Ltd."

INDEX TO ADVERTISERS
April 1960

Adjustable Fixture Co.	64A
Advance Transformer Co.	1A
Alkco Manufacturing Co.	55A
American Louver Co.	Inside Back Cover
Certified Ballast Manufacturers	9A
Cirvac Plastics	62A
Contrex Co.	60A
Corning Glass Works	36A
Day-Brite Lighting Inc.	34A-34A
Garden City Plating & Mfg. Co.	24A
General Electric Co., Lamp	33A
Edwin F. Guth Co.	Back Cover
Holophane Co., Inc.	10A
Jefferson Electric Co.	58A
Keystone Electric Mfg. Co.	2A
Kopp Glass Inc.	45A
KSH Plastics, Inc.	28A-29A
Lightolier	53A
Litecontrol Corp.	30A
Macmillan Co.	59A
R. A. Manning Co.	66A
McPhilben Lighting Co.	64A
Meierjohan-Wengler	60A
Metalcraft Products Co., Inc.	62A
Miller Co.	49A
Monsanto Chemical Co.	68A
NL Corp.	66A
Owens-Corning Fiberglas Corp.	20A-21A
Revere Electric Mfg. Co.	23A
RLM Standards Institute	16A
W. J. Ruscoe Co.	66A
Sandee Manufacturing Co.	50A
Sheffield Plastics, Inc.	4A
Smithcraft Corp.	27A
Smoot-Holman Co.	56A
Sola Electric Co.	14A-15A
Steber Manufacturing Co.	65A
Stonco Electric Products Co.	63A
Sunbeam Lighting Co.	39A
Sylvania Electric Products Inc.	19A, 61A
Thatcher Glass Mfg. Co.	67A
Union Carbide Plastics Co., Div. of Union Carbide Corp.	13A
Union Metal Mfg. Co.	57A
United Mineral & Chemical Corp.	43A
Wakefield Co.	Inside Front Cover
Westinghouse Electric Corp., Lamp Div.	40A-41A
Wide-Lite Corp.	47A

KEELITE
GLASSWARE FOR LIGHTING

heat-resisting ceiling diffusers



wide range of sizes available from stock

These diffusers are made of homogeneous heat-resisting opal glass. They are available in several sizes from 6 inches to 12 inches in both square and round styles.

Our modern, highly-mechanized production methods enable us to furnish *heat-resisting* glassware for lighting at the same cost as you are now paying for ordinary glass. We invite you to check this point at your earliest opportunity.

Thatcher Glass

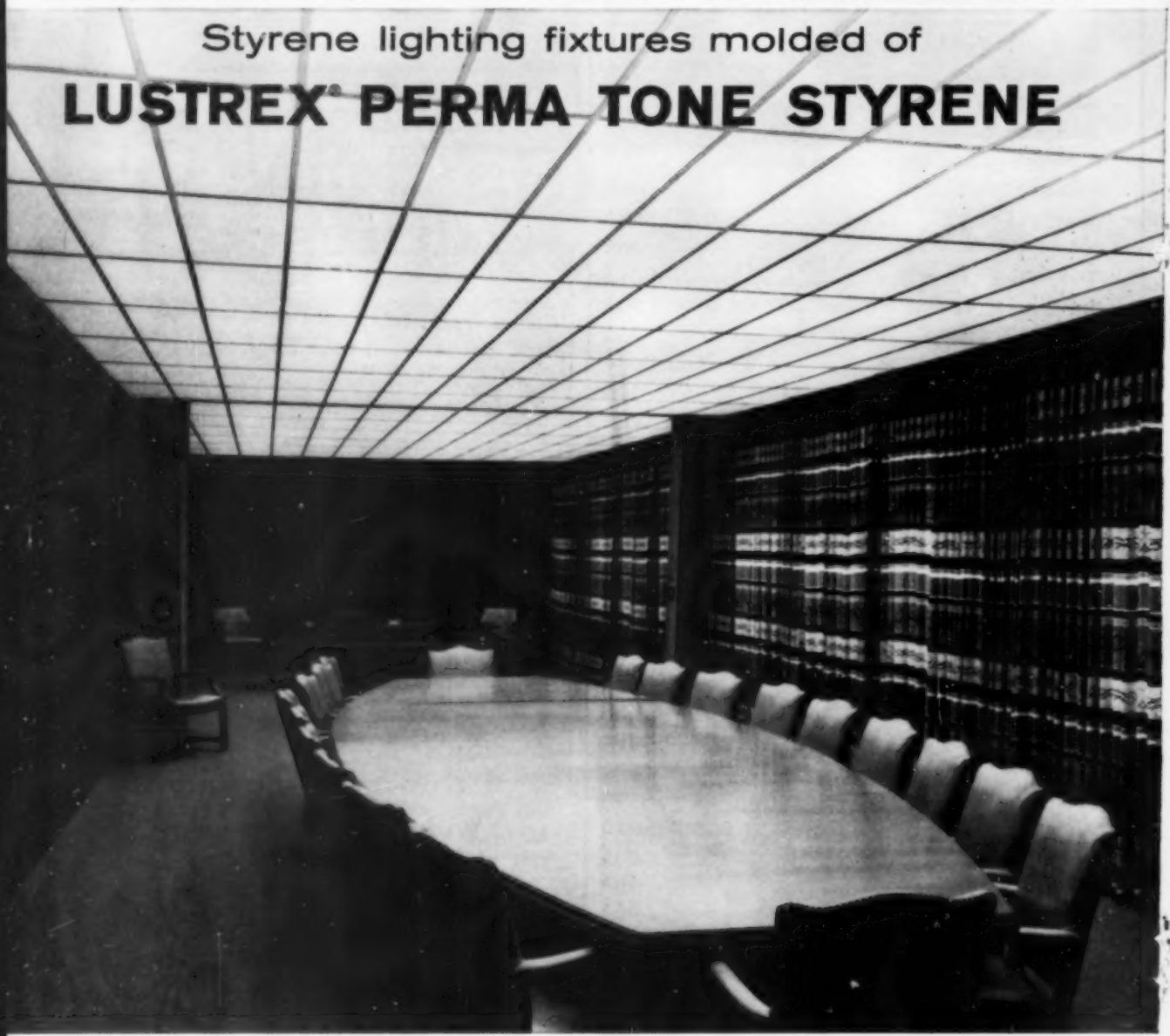
Write for complete specifications and prices

THATCHER GLASS MANUFACTURING CO., INC. JEANNETTE, PA.

ABOVE ALL:

Styrene lighting fixtures molded of

LUSTREX® PERMA TONE STYRENE



Lustrex perma tone has proven itself in use since 1956. More Lustrex perma tone is used for lighting fixtures than any other ultraviolet light-stabilized styrene.

In clear white and a complete color range, it exceeds IES-NEMA-SPI joint specifications for ultraviolet light-stabilized styrene. With perma tone you can create low cost large areas of illumination with good diffusion, dimensional stability, and uniform light distribution.

New Impact Lustrex perma tone provides extra toughness and flexibility for snap-fitting to metal parts, high resistance to abnormal abuse, lighter weight through thinner walls. For free technical report on both regular and impact Lustrex perma tone styrene, including accelerated aging test results and other valuable data on styrene in lighting fixtures, write to Monsanto Chemical Company, Plastics Division, Room 727, Springfield 2, Massachusetts.

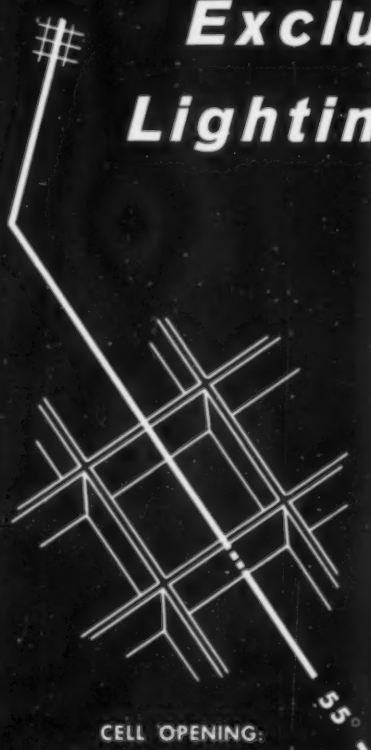
LUSTREX: Reg. U.S. Pat. Off

Monsanto®

MONSANTO ORIGINATOR IN **PLASTICS**

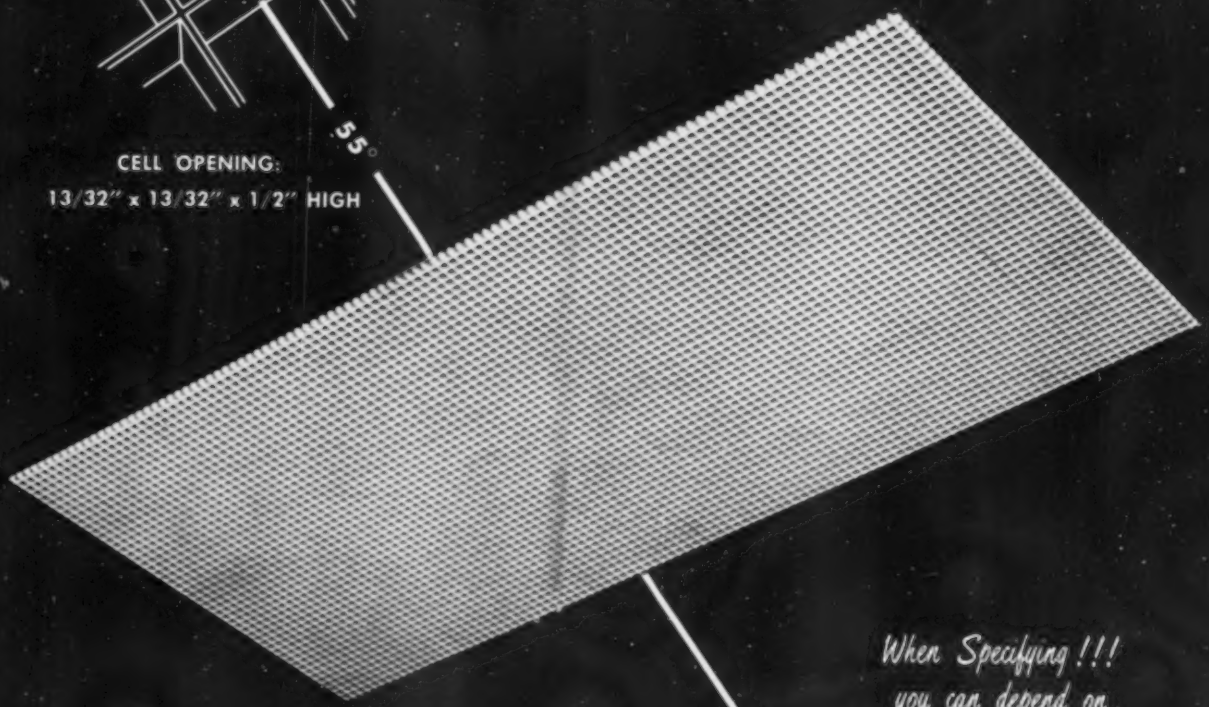
NEW!

Exclusive 55° Angle Lighting Louver Diffuser



CELL OPENING:
13/32" x 13/32" x 1/2" HIGH

Developed to meet todays and tomorrows higher lighting levels—For use in Individual fixtures, Modular or Large Area illumination with unexcelled diffusion—Developed to meet and exceeds IES-NEMA SPI joint specifications for stabilized styrene—True translucent white and a wide range of colors—Light weight for easy handling, installation and maintenance—Dimensionally stable—Low cost—Available in 45° and 42° shielding also.



When Specifying!!! you can depend on American Louvers...

Light shielding louvers is our one and only *most important product*, developed, designed and manufactured by American louver, consultants to the lighting industry since 1939, assuring you the finest in Plastic Louvers.

For pertinent facts on American louvers, write for bulletin 33am and new 3 color catalog—Just off the press.

american louver company

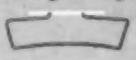
4240 N. SAYRE AVENUE • CHICAGO 34, ILLINOIS

Guth
LIGHTING
since 1902

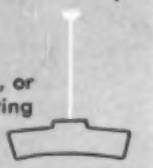
Your choice of Concave GrateLite Louver Diffuser*, or Concave Prismoid GrateLite Louver-Lens**.

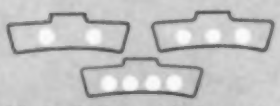
One-piece plastic side wings are tubular for added strength, lower side brightness, plus "reflector" efficiency. Ends are capped to simplify maintenance.

Concave GrateLites *hinge separately* from sturdy steel end plates for extra strength and easier servicing. No glue in Gateway!



Pendant mounting, or adaptable for close-ceiling mounting with top plates. For schools, stores and offices.





Available in 2, 3, or 4 light units ... in the same fixture width. 4' or 8' lengths.

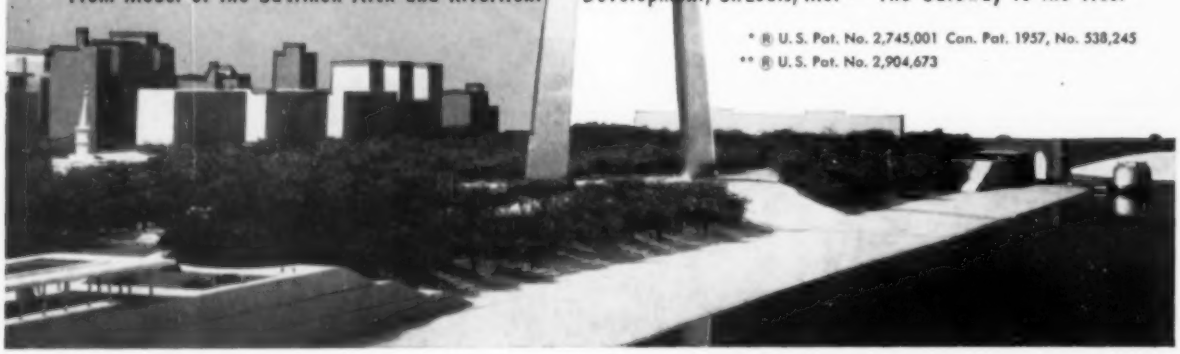
YOUR
gateway
...TO RUGGED STRENGTH AND BEAUTY IN A CONCAVE PLASTIC FIXTURE

New Guth Gateway brings you "eye styled" beauty with sharp-line design and quality illumination. A new concept of fixture construction! Plastic is basic . . . but no wrap-a-round. Concave GrateLite bottoms hinge separately.

WRITE FOR GUTH
GATEWAY BROCHURE TODAY!

THE EDWIN F. GUTH CO.
2615 WASHINGTON BLVD., BOX 7079, ST. LOUIS 77, MO.

From Model of the Saarinen Arch and Riverfront Development, St. Louis, Mo.—"The Gateway to the West"



* Ⓡ U. S. Pat. No. 2,745,001 Can. Pat. 1957, No. 538,245
** Ⓡ U. S. Pat. No. 2,904,673